

MULTIPLE CHOICE:

1. In the following equation,

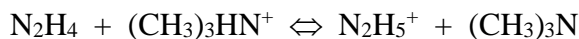


the HF is a Brønsted-Lowry

- A. acid accepting protons
 - B. base accepting protons
 - C. acid donating protons
 - D. base donating protons
2. The conjugate base of $\text{HSO}_3^-(aq)$ is

- A. $\text{H}_2\text{SO}_3(aq)$
- B. $\text{HSO}_3\text{OH}(l)$
- C. $\text{SO}_3(g)$
- D. $\text{SO}_3^{2-}(aq)$

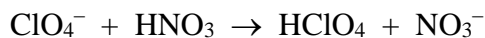
3. In the following equation



a conjugate acid-base pair is

- A. N_2H_4 and $(\text{CH}_3)_3\text{NH}^+$
- B. N_2H_4 and $(\text{CH}_3)_3\text{N}$
- C. N_2H_5^+ and N_2H_4
- D. $(\text{CH}_3)_3\text{NH}^+$ and N_2H_5^+

4. In the equation

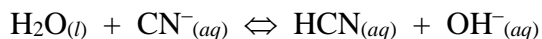
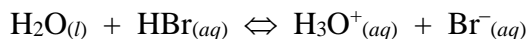


the order, from left to right, for Brønsted-Lowry acids and bases is

- A. acid + base \rightleftharpoons base + acid
 - B. acid + base \rightleftharpoons acid + base
 - C. base + acid \rightleftharpoons base + acid
 - D. base + acid \rightleftharpoons acid + base
5. The equation showing the acid form of an indicator reacting with a basic solution is
- A. $\text{In}^-(aq) + \text{OH}^-(aq) \rightleftharpoons \text{HIn}(aq)$
 - B. $\text{HIn}(aq) + \text{OH}^-(aq) \rightleftharpoons \text{H}_2\text{O}(l) + \text{In}^-(aq)$
 - C. $\text{In}^-(aq) + \text{H}_3\text{O}^+(aq) \rightleftharpoons \text{HIn}(aq) + \text{H}_2\text{O}(aq)$
 - D. $\text{HIn}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{In}^-(aq)$

ACID/BASE REVIEW

6. Note the following reactions involving water



Because of this behaviour, water is classified as

- A. neutral
 - B. a salt
 - C. amphiprotic
 - D. a solvent
7. 0.200 moles of hydrogen chloride gas (HCl) is dissolved in water and made up to a volume of 4.00 L of solution. What is the molarity of the H_3O^+ ion?
- A. 0.200 M
 - B. 20.0 M
 - C. 5.00×10^{-2} M
 - D. 1.37×10^{-3} M
8. The $[\text{H}_3\text{O}^+]$ in an aqueous solution of 2.0×10^{-3} M NaOH (strong base) is
- A. 5.0×10^{-12} M
 - B. 5.0×10^{-3} M
 - C. 2.0×10^{-12} M
 - D. 5.0×10^{-11} M
9. Given:
- $$\text{HPO}_4^{2-}(aq) + \text{NH}_4^+(aq) \rightleftharpoons \text{H}_2\text{PO}_4^-(aq) + \text{NH}_3(aq)$$
- the strongest acid in the above equation is
- A. NH_4^+
 - B. HPO_4^{2-}
 - C. NH_3
 - D. H_2PO_4^-
11. A formula for a salt is
- A. Na_2HPO_4
 - B. H_3PO_4
 - C. $\text{C}_6\text{H}_5\text{COOH}$
 - D. $\text{Cu}(\text{NH}_3)_4^{2+}$

ACID/BASE REVIEW

12. The salt which will undergo hydrolysis in water is
- A. K_2I^+
 - B. KNO_3
 - C. KCN
 - D. KCl
13. Which of the following equations best illustrates the hydrolysis of Na_2CO_3 ?
- A. $\text{Na}_2\text{CO}_{3(s)} + \text{H}_2\text{O}_{(l)} \Leftrightarrow \text{Na}_2\text{O}_{(aq)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$
 - B. $\text{CO}_3^{2-}_{(aq)} + \text{H}_2\text{O}_{(l)} \Leftrightarrow \text{HCO}_3^{-}_{(aq)} + \text{H}_3\text{O}^{+}_{(aq)}$
 - C. $\text{Na}_2\text{CO}_{3(s)} \rightarrow 2\text{Na}^{+}_{(aq)} + \text{CO}_3^{2-}_{(aq)}$
 - D. $\text{Na}_2\text{CO}_{3(s)} + \text{H}_2\text{O}_{(l)} \Leftrightarrow \text{Na}_2\text{CO}_{4(aq)} + \text{H}_{2(g)}$
14. Which of the expressions given below illustrates a correct expression for pH?
- A. $\log [\text{H}_3\text{O}^+]$
 - B. $-\log [\text{H}_3\text{O}^+]^2$
 - C. $-\log [\text{H}_3\text{O}^+]$
 - D. $-\log (1/[\text{H}_3\text{O}^+])$
15. What is the hydronium ion concentration, $[\text{H}_3\text{O}^+]$, of a 0.00100 M sodium hydroxide (NaOH) solution?
- A. $1.00 \times 10^{-3} \text{ M}$
 - B. 11.0 M
 - C. $1.00 \times 10^{-11} \text{ M}$
 - D. 0.00100 M
16. What is the pH of a 0.00100 M perchloric (HClO_4) acid solution?
- A. 0.00100
 - B. 1.00×10^{-3}
 - C. 3.00
 - D. 13.0

ACID/BASE REVIEW

17. The $[\text{H}_3\text{O}^+]$ in a hydrochloric acid solution is 1.00×10^{-3} M. What is the pOH of the solution?

- A. 3.00
- B. 11.0
- C. 0.00100
- D. 1.0×10^{-3}

21. Given that
$$K_b = \frac{[\text{NH}_3][\text{OH}^-]}{[\text{NH}_4^+]}$$
 and
$$K_a = \frac{[\text{NH}_4^+][\text{H}_3\text{O}^+]}{[\text{NH}_3]}$$

and
$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$$

the correct relationship between these expressions is

- A. $K_w = K_a \times K_b$
- B. $K_w = \frac{K_a}{K_b}$
- C. $K_w = \frac{1}{K_a \times K_b}$
- D. $K_w = \frac{K_b}{K_a}$

22. An aqueous solution of aniline, $\text{C}_6\text{H}_5\text{NH}_2$, is in equilibrium with its conjugate acid, $\text{C}_6\text{H}_5\text{NH}_3^+$. If the numerical value of K_b for aniline is 4.30×10^{-10} , the value of K_a for its conjugate acid $\text{C}_6\text{H}_5\text{NH}_3^+$ is

- A. 4.30×10^4
- B. 2.3×10^{-5}
- C. 5.38×10^{-10}
- D. 4.30×10^{-10}

23. An aqueous solution of acetic acid, CH_3COOH , is in equilibrium with its conjugate base, CH_3COO^- . If the numerical value of K_a for CH_3COOH is 1.80×10^{-5} , the value of K_b for its conjugate base, CH_3COO^- is

- A. 1.80×10^{-5}
- B. 5.56×10^{-10}
- C. 3.24×10^{-10}
- D. 1.80×10^9

ACID/BASE REVIEW

24. Given that



The equilibrium concentration of an ammonia (NH_3) solution is 0.500 M. The pOH of the solution is

- A. 11.5
- B. 8.95
- C. 2.52
- D. 2.00

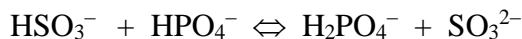
27. In the equation $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NH}_3$, how does the H_2O act?

- A. As a Brønsted-Lowry acid donating protons.
- B. As a Brønsted-Lowry acid accepting protons.
- C. As a Brønsted-Lowry base donating protons.
- D. As a Brønsted-Lowry base accepting protons.

28. Which one of the following is the conjugate base of H_2PO_4^- ?

- A. HPO_4^{2-}
- B. H_3PO_4
- C. PO_4^{3-}
- D. H_3PO_3

29. Which one of the following is the correct order for the Brønsted acids or bases in the equation



- A. acid + base \rightleftharpoons acid + base
- B. acid + base \rightleftharpoons base + acid
- C. base + acid \rightleftharpoons acid + base
- D. base + acid \rightleftharpoons base + acid

30. Which of the following is the weakest acid?

- A. 0.010 M HCl
- B. 0.10 M HBr
- C. 0.10 M HI
- D. 0.10 M HF

ACID/BASE REVIEW

31. Which one of the following equation shows the basic form of an indicator HIn reacting in an acidic solution?
- A. $\text{In}^{-}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq}) \rightleftharpoons \text{HIn}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- B. $\text{HIn}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq}) \rightleftharpoons \text{H}_2\text{In}^{+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- C. $\text{In}^{-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HIn}(\text{aq}) + \text{OH}^{-}(\text{aq})$
- D. $\text{HIn}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightleftharpoons \text{In}^{-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
32. The indicator methyl red has a K_a value of 4.00×10^{-6} . If a 1.00×10^{-3} M solution of the indicator is used, what will be the $[\text{H}_3\text{O}^{+}]$ at the end point, where the colour is orange (i.e. intermediate between red and yellow)?
- A. 4.00×10^{-9} M
- B. 4.00×10^{-6} M
- C. 2.00×10^{-3} M
- D. 4.00×10^{-3} M
33. Which one of the following salts will show the greatest amount of hydrolysis in water if equal concentrations are used?
- A. NaI
- B. NaNO_2
- C. Na_3PO_4
- D. Na_2SO_4
34. Which one of the following sets shows the order of increasing pH of the aqueous solutions of the three salts if equal concentrations are used?
- A. NH_4Cl , K_2SO_4 , Na_2CO_3
- B. K_2SO_4 , NH_4Cl , Na_2CO_3
- C. Na_2CO_3 , K_2SO_4 , NH_4Cl
- D. NH_4Cl , Na_2CO_3 , K_2SO_4
35. Which one of the following statements about HNO_3 and HNO_2 is **TRUE**, given that HNO_3 is a stronger acid than HNO_2
- A. NO_2^{-} ion is a stronger base than NO_3^{-} ion.
- B. NO_3^{-} ion is a better proton acceptor than NO_2^{-} ion.
- C. The bond between H and O in undissociated HNO_3 is stronger than the bond between H and O in undissociated HNO_2 .
- D. A solution of 1 M HNO_3 contains fewer particles than a solution of 1 M HNO_2 if equal volumes are compared.

ACID/BASE REVIEW

36. What is the hydronium ion concentration, $[H_3O^+]$, of a solution whose pH is 6.00?
- A. 1.0×10^{-8} M
 - B. 1.0×10^{-6} M
 - C. 6.0 M
 - D. 1.0×10^6 M
37. What is the pOH of a 0.012 M solution of sodium hydroxide, NaOH?
- A. 1.03
 - B. 1.9
 - C. 1.92
 - D. 12.08
38. What is the pH of the solution which results when 100.0 mL of a 0.050 M solution of NaOH is reacted with 200.0 mL of a 0.025 M solution of HCl?
- A. 6.00
 - B. 7.00
 - C. 8.0
 - D. 9.00

Refer to the following information when answer in questions 41 and 42.



$$K_a(HNO_2) = 5.1 \times 10^{-4}$$

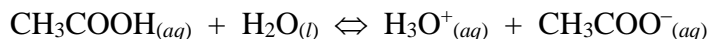
41. What is the pH of an aqueous solution of nitrous acid, HNO_2 , when its equilibrium concentration is 1.0×10^{-3} M?
- A. 3.00
 - B. 3.15
 - C. 6.00
 - D. 6.29
42. What is K_b for the nitrite ion, NO_2^- , the conjugate base of nitrous acid?
- A. 2.0×10^{-11}
 - B. 5.1×10^{-4}
 - C. 2.0×10^{-3}
 - D. 2.2×10^{-2}

ACID/BASE REVIEW

44. What is the pH of a 0.0025 M solution of lime water, $\text{Ca}(\text{OH})_2$?

- A. 2.30
- B. 2.60
- C. 11.40
- D. 11.70

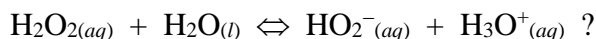
47. The following equation represents the dissociation of acetic acid, CH_3COOH , in water:



Which one of the following is the expression for the K_a of acetic acid?

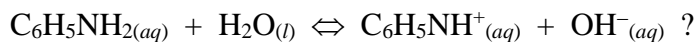
- A. $K_a = [\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]$
- B. $K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{H}_2\text{O}][\text{CH}_3\text{COOH}]}$
- C. $K_a = \frac{[\text{CH}_3\text{COOH}][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COO}^-]}$
- D. $K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$

48. Which one of the following species is the weaker base in the equation



- A. $\text{HO}_2^-_{(aq)}$
- B. $\text{H}_2\text{O}_{(l)}$
- C. $\text{H}_2\text{O}_2_{(aq)}$
- D. $\text{H}_3\text{O}^+_{(aq)}$

49. Which one of the following orders is correct for the Brønsted-Lowry acids and bases in the equation

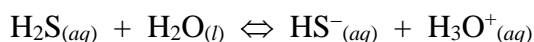


- A. acid + base \rightleftharpoons acid + base
- B. acid + base \rightleftharpoons base + acid
- C. base + acid \rightleftharpoons acid + base
- D. base + acid \rightleftharpoons base + acid

ACID/BASE REVIEW

50. Which one of the following statements **BEST** describes a Brønsted-Lowry base?
- A. It will accept an H^+ .
 - B. It will donate an H^+ .
 - C. It will accept an OH^- .
 - D. It will donate an OH^- .
51. The indicator quinaldine red has a colourless acid form and a pink base form. Its K_a is 2.5×10^{-2} . Which one of the following descriptions of a aqueous solution of quinaldine red at a pH of 6 is correct?
- A. The solution is pink
 - B. The solution is colourless
 - C. The [acid form] > [base form]
 - D. The [acid form] = [base form]

52. Which one of the following K_a expressions for the dissociation of hydrogen sulfide in water is correct given that the equation for the dissociation is



- A. $K_a = \frac{[\text{HS}^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{S}][\text{H}_2\text{O}]}$
 - B. $K_a = \frac{[\text{H}_2\text{S}][\text{H}_2\text{O}]}{[\text{HS}^-][\text{H}_3\text{O}^+]}$
 - C. $K_a = \frac{[\text{H}_2\text{S}]}{[\text{HS}^-][\text{H}_3\text{O}^]}$
 - D. $K_a = \frac{[\text{HS}^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{S}]}$
53. Which one of the following expression is the correct expression for $\text{p}K_w$?
- A. $\text{p}K_w = \frac{1}{K_w}$
 - B. $\text{p}K_w = (\text{pH})(\text{pOH})$
 - C. $\text{p}K_w = \text{pH} + \text{pOH}$
 - D. $\text{p}K_w = \text{antilog } K_w$
54. An aqueous solution of the base hydrazine (N_2H_4) is in equilibrium with its conjugate acid, N_2H_5^+ . If the K_b for N_2H_4 is 1.70×10^{-6} at 20°C , what is the K_a for N_2H_5^+ ?
- A. 5.88×10^{-9}
 - B. 1.70×10^{-6}
 - C. 5.88×10^5
 - D. 1.70×10^8

ACID/BASE REVIEW

55. Water at 25°C has a pH of 7 and the equation for dissociation is



Water at 80°C could **BEST** be described as

- A. basic.
 - B. acidic.
 - C. neutral with a pH less than 7.
 - D. neutral with a pH greater than 7.
56. What is the pH of a 2.0 M solution of benzoic acid ($\text{C}_6\text{H}_5\text{COOH}$) ?
- A. 1.94
 - B. 2.24
 - C. 3.88
 - D. 4.48
64. Which one of the following will occur when $\text{NaF}_{(s)}$ is added to a 0.5 M HF solution?
- A. The pH of the HF solution decreases.
 - B. The pH of the HF solution remains the same.
 - C. The acidity of the HF solution decreases.
 - D. The acidity of the HF solution increases.
65. Which one of the following ions is the conjugate base of $\text{Al}(\text{H}_2\text{O})_6^{3+}_{(aq)}$?
- A. $\text{Al}(\text{H}_3\text{O})_6^{4+}_{(aq)}$
 - B. $\text{Al}(\text{H}_2\text{O})_6^{2+}_{(aq)}$
 - C. $\text{Al}(\text{H}_2\text{O})_5\text{OH}^{2+}_{(aq)}$
 - D. $\text{Al}(\text{H}_2\text{O})_6\text{OH}^{2+}_{(aq)}$
66. Which of the following solutions will have the greatest $[\text{H}_3\text{O}^+]$
- A. 0.05 M HNO_2
 - B. 0.10 M HCl
 - C. 0.15 M HNO_3
 - D. 0.20 M HCN

ACID/BASE REVIEW

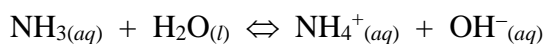
67. In which of the following equations is HSO_3^- acting as a base?

- A. $2\text{HSO}_3^-(aq) \rightarrow \text{S}_2\text{O}_5^{2-}(aq) + \text{H}_2\text{O}(l)$
- B. $\text{HSO}_3^-(aq) + \text{H}_3\text{O}^+(aq) \rightarrow \text{H}_2\text{SO}_3(aq) + \text{H}_2\text{O}(l)$
- C. $\text{HSO}_3^-(aq) + \text{OH}^-(aq) \rightarrow \text{SO}_3^{2-}(aq) + \text{H}_2\text{O}(l)$
- D. $\text{HSO}_3^-(aq) + \text{HPO}_4^{2-}(aq) \rightarrow \text{SO}_3^{2-}(aq) + \text{H}_2\text{PO}_4^-(aq)$

69. A common property of 6 M solutions of strong acids and bases is that they

- A. are amphiprotic
- B. conduct electricity well
- C. have the same pH
- D. change red litmus to blue

70. The equation for the ionization of ammonia is



The K_b expression for this reaction is

- A. $\frac{[\text{NH}_3]}{[\text{NH}_4^+][\text{OH}^-]}$
- B. $\frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]}$
- C. $\frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3][\text{H}_2\text{O}]}$
- D. $\frac{[\text{NH}_3][\text{H}_2\text{O}]}{[\text{NH}_4^+][\text{OH}^-]}$

71. The pH of a solution is found to be 5.00. What is the value of pOH for the same solution?

- A. 2.00
- B. 5.00
- C. 9.00
- D. 12.00

72. The word “hydrolysis” in chemistry refers to the

- A. reaction of water with substances
- B. reaction of hydrogen with ions
- C. removal of water from a compound
- D. removal of hydrogen from a compound.

ACID/BASE REVIEW

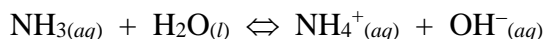
73. Which of the following salts dissolved in distilled water will produce the most acidic solution if all solutions are at 0.10 M ?

- A. NH_4Cl
- B. CrCl_3
- C. FeCl_3
- D. AlCl_3

74. What is the $[\text{H}_3\text{O}^+]$ in a solution with $[\text{OH}^-] = 2.7 \times 10^{-4} \text{ M}$?

- A. $3.7 \times 10^{-11} \text{ M}$
- B. $7.3 \times 10^{-8} \text{ M}$
- C. $2.7 \times 10^{-4} \text{ M}$
- D. $3.7 \times 10^{-4} \text{ M}$

75. The K_b value for NH_3 is 1.8×10^{-5} . What is the $[\text{OH}^-]$ in a 0.1 M solution of NH_3 ?

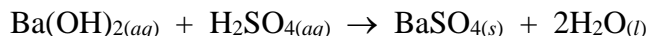


- A. $2.7 \times 10^{-6} \text{ M}$
- B. $1.2 \times 10^{-4} \text{ M}$
- C. $1.7 \times 10^{-3} \text{ M}$
- D. $4.2 \times 10^{-3} \text{ M}$

76. The K_a value for H_2CO_3 is 4.4×10^{-7} . What is the K_b value for its conjugate base?

- A. 4.6×10^{-11}
- B. 2.3×10^{-8}
- C. 2.3×10^{-6}
- D. 2.1×10^{-4}

77. What type of reaction does the following equation represent?



- A. hydrolysis
- B. decomposition
- C. neutralization
- D. oxidation-reduction

78. What volume of a $4.00 \times 10^{-2} \text{ M}$ HCl solution is needed to neutralize $2.00 \times 10^{-1} \text{ L}$ of a $1.00 \times 10^{-2} \text{ M}$ LiOH solution?

- A. $5.00 \times 10^{-2} \text{ L}$
- B. $1.00 \times 10^{-1} \text{ L}$
- C. $2.00 \times 10^{-1} \text{ L}$
- D. $5.00 \times 10^{-1} \text{ L}$

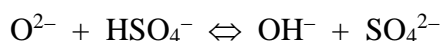
79. 0.45 g of an unknown **diprotic** acid required 4.5×10^{-3} mol of NaOH for complete neutralization. The mass of one mole of the acid is

- A. 4.5×10^1 g
- B. 1.0×10^2 g
- C. 2.0×10^2 g
- D. 4.0×10^2 g

83. Which of the following compounds is a base when in solution?

- A. HCl
- B. NH_3
- C. NaCl
- D. CH_3COOH

84. Which two substances act as the Brønsted-Lowry acids in the following equilibrium?

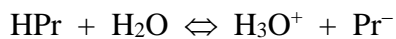


- A. O^{2-} and SO_4^{2-}
- B. O^{2-} and OH^-
- C. HSO_4^- and OH^-
- D. HSO_4^- and SO_4^{2-}

85. Which of the following compounds is a strong base in solution?

- A. LiOH
- B. NaHS
- C. K_2CO_3
- D. NH_4Cl

86. Consider the following equilibrium reaction for the indicator propyl red, HPr:



If NaOH is added, this equilibrium shifts to the

- A. left as $[\text{HPr}]$ decreases.
- B. right as $[\text{HPr}]$ increases.
- C. left as $[\text{H}_3\text{O}^+]$ increases.
- D. right as $[\text{H}_3\text{O}^+]$ decreases.

87. Which of the following reactions will favour reactants at equilibrium?

- A. $\text{HF} + \text{HS}^- \rightleftharpoons \text{F}^- + \text{H}_2\text{S}$
- B. $\text{HF} + \text{OH}^- \rightleftharpoons \text{F}^- + \text{H}_2\text{O}$
- C. $\text{HF} + \text{SO}_4^{2-} \rightleftharpoons \text{F}^- + \text{HSO}_4^-$
- D. $\text{HF} + \text{CH}_3\text{COO}^- \rightleftharpoons \text{F}^- + \text{CH}_3\text{COOH}$

88. The expression for the ionization constant of water is

- A. $K_w = \frac{[\text{H}_3\text{O}^+]}{[\text{OH}^-]}$
- B. $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$
- C. $K_w = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$
- D. $K_w = [\text{H}_3\text{O}^+] + [\text{OH}^-]$

89. At 40°C, $K_w = 3.1 \times 10^{-14}$. Water at 40°C may be described as

- A. acidic with $[\text{H}_3\text{O}^+] = 3.1 \times 10^{-7}$ M.
- B. acidic with $[\text{H}_3\text{O}^+] = 1.8 \times 10^{-7}$ M.
- C. neutral with $[\text{H}_3\text{O}^+] = 1.8 \times 10^{-7}$ M.
- D. neutral with $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-7}$ M.

90. In a solution at 25°C where $[\text{H}_3\text{O}^+] = 2.0$ M, the $[\text{OH}^-]$ is

- A. 5.0×10^{-15} M
- B. 2.0×10^{-14} M
- C. 5.0×10^{-13} M
- D. 12 M

91. Consider the following equilibrium constant expression:

$$K_{eq} = \frac{[\text{HCO}_3^-][\text{OH}^-]}{[\text{CO}_3^{2-}]}$$

This expression represents

- A. K_b for CO_3^{2-}
- B. K_a for CO_3^{2-}
- C. K_b for HCO_3^-
- D. K_a for HCO_3^-

ACID/BASE REVIEW

92. The net ionic equation for the hydrolysis that occurs when KF is dissolved in water is
- A. $\text{KF}_{(s)} \rightarrow \text{K}^+_{(aq)} + \text{F}^-_{(aq)}$
 - B. $\text{F}^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{HF}_{(aq)} + \text{OH}^-_{(aq)}$
 - C. $\text{KF}_{(s)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{HKF}^+_{(aq)} + \text{OH}^-_{(aq)}$
 - D. $\text{KF}_{(s)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{HF}_{(aq)} + \text{KOH}_{(aq)}$

93. Which of the following 0.10 M salt solutions is neutral?

- A. KI
- B. SrS
- C. NH_4Cl
- D. Na_2CO_3

94. The pH of two solutions is measured as follows:

Solution A pH = 2.0
Solution B pH = 6.0

The data suggest that the $[\text{H}_3\text{O}^+]$ in solution A is

- A. $\frac{1}{3}$ of that in solution B.
 - B. 3 times that in solution B.
 - C. 0.0001 of that in solution B.
 - D. 10,000 times that in solution B.
95. A substance which undergoes a colour change with a change in pH is known as
- A. an acid-base buffer.
 - B. an acid-base titration.
 - C. an acid-base indicator.
 - D. a salt which hydrolyzes.
96. A student uses several indicators to determine the pH of a solution and obtains the following data:

Indicator	Thymol blue	Methyl orange	Methyl red	Phenol red	Phenolphthalein
Colour	yellow	yellow	red	yellow	colourless

The pH of the solution is

- A. 2.8
- B. 4.6
- C. 6.3
- D. 8.1

ACID/BASE REVIEW

97. In a solution of pH 9.52, the $[\text{OH}^-]$ is
- A. $3.0 \times 10^{-10} \text{ M}$
 - B. $1.7 \times 10^{-5} \text{ M}$
 - C. $3.3 \times 10^{-5} \text{ M}$
 - D. 4.48 M
98. The pH of a 0.1 M Na_2SO_3 solution is approximately
- A. 1
 - B. 7
 - C. 10
 - D. 14
99. A property that is exhibited by acids and bases in solution is that they both
- A. taste bitter.
 - B. react with Zn.
 - C. conduct electricity.
 - D. turn methyl violet to blue.
100. The conjugate acid of PO_4^{3-} is
- A. H_3O^+
 - B. HPO_4^{2-}
 - C. H_3PO_4
 - D. H_2PO_4^-
101. Consider the following:
- $$\text{SO}_4^{2-} + \text{HNO}_2 \rightleftharpoons \text{HSO}_4^- + \text{NO}_2^-$$
- Equilibrium would favour
- A. the products since HSO_4^- is a weaker acid than HNO_2 .
 - B. the reactants since HSO_4^- is a weaker acid than HNO_2 .
 - C. the products since HSO_4^- is a stronger acid than HNO_2 .
 - D. the reactants since HSO_4^- is a stronger acid than HNO_2
102. The strongest base that can exist in water is
- A. O^{2-}
 - B. NH_3
 - C. NH_2^-
 - D. OH^-

ACID/BASE REVIEW

103. Which of the following acids will have the greatest $[\text{OH}^-]$?
- A. 1.0 M HI
 - B. 1.0 M HF
 - C. 1.0 M HCN
 - D. 1.0 M H_2SO_4
104. When either HCl or NaOH is added to water at 25°C , the fraction of water molecules ionized is
- A. less than in pure water.
 - B. greater than in pure water.
 - C. equal to that in pure water.
 - D. always equal to 1.00×10^{-14} .
105. The value of K_b for F^- is
- A. 1.5×10^{-11}
 - B. 6.7×10^{-4}
 - C. 1.5×10^{-3}
 - D. 1.5×10^3
106. A substance has a $K_a = 4.0 \times 10^{-12}$. From this information it can be concluded that the substance is a
- A. weak base.
 - B. weak acid.
 - C. strong base
 - D. strong acid.
107. A student heats a sample of water and measures the $[\text{H}_3\text{O}^+]$ at various temperatures giving the following data:

Temperature ($^\circ\text{C}$)	0	20	40	60
$[\text{H}_3\text{O}^+]$	$4.4 \times 10^{-8} \text{ M}$	$8.2 \times 10^{-8} \text{ M}$	$1.3 \times 10^{-7} \text{ M}$	$3.2 \times 10^{-7} \text{ M}$

These data show that as water is heated

- A. the pH increases.
- B. it becomes more acidic.
- C. it is ionized to a greater extent.
- D. $[\text{H}_3\text{O}^+]$ increases while $[\text{OH}^-]$ decreases.

ACID/BASE REVIEW

111. The indicator Congo red, HInd, ionizes according to the following equation:



When added to solutions of HCl of various concentrations, Congo red displayed the following colours:

[HCl]	Colour
0.10 M	red
0.010 M	orange
0.0010 M	yellow

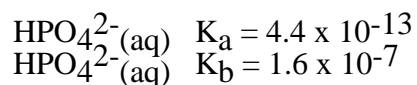
When the colour orange is observed,

- A. $[\text{HInd}] = [\text{HCl}]$
 - B. $[\text{HInd}] = [\text{Ind}^-]$
 - C. $[\text{HInd}] = [\text{H}_3\text{O}^+]$
 - D. $[\text{HInd}] = K_a[\text{HInd}]$
112. The pH of 0.60 M HClO_4 is
- A. -0.60
 - B. 0.22
 - C. 0.60
 - D. 13.78
113. The approximate K_a value for the indicator thymolphthalein is
- A. 1×10^{-10}
 - B. 1×10^{-4}
 - C. 4
 - D. 10
114. Consider the following 1.0 M solutions:
- NaOH, HCl, and NaCl
- Which of the following lists these solutions in **increasing** order of pH?
- A. NaOH, HCl, NaCl
 - B. HCl, NaOH, NaCl
 - C. NaOH, NaCl, HCl
 - D. HCl, NaCl, NaOH

WRITTEN RESPONSE QUESTIONS

Your steps and assumptions leading to a solution must be written. In questions involving calculation, full marks will not be given for providing only an answer. Students will be expected to communicate the knowledge and understanding of chemical principles in a clear and logical manner.

1. Calculate K_b for $H_2BO_3^-$, the conjugate base for boric acid, H_3BO_3 . **(2 marks)**
2. Write the net ionic equation for the following reaction : potassium hydroxide neutralized by acetic acid. **(2 marks)**
3. A 0.10 M solution of a weak acid HX has a pH of 4.26. Calculate the value of K_a for HX. **(3 marks)**
4. Calculate the pH of a solution made by dissolving 3.75 g of RbOH in 79.8 mL of 0.18 M HNO_3 . Assume no volume change. **(5 marks)**
5. Write the equilibrium equation for the reaction of the HS^- ion with water to produce a basic solution. State whether the reactants or products are favoured. **(2 marks)**
6. The K_a and K_b values for the HPO_4^{2-} ion in water are given below :

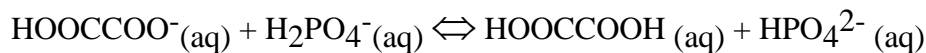


Indicate whether an aqueous solution of Na_2HPO_4 is basic or acidic, and explain your answer with reference to the K_a and K_b values given above. **(2 marks)**

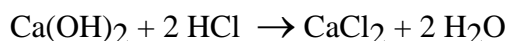
7. Calculate the mass of $NaOH(s)$ that would have to be added to 10.0 mL of a 2.00 M HNO_3 solution to obtain a pH of 1.00. **(4 marks)**
10. A 0.60 M solution of the weak acid HX is found to have a pH = 4.30. Determine K_a for this acid. **(3 marks)**
11. Calculate the $[H_3O^+]$ of a solution with a pOH of 3.86. **(2 marks)**
12. Give the formula for each of the following :
 - a) a third row amphoteric hydroxide. **(1 mark)**
 - b) a third row basic hydroxide. **(1 mark)**
13. Determine the $[H^+]$ in 2.4 M HF. **(2 marks)**
14. If you were given two unknown acids of equal concentration, briefly describe how you would identify the stronger acid. What testing material or instrument would you use, and how would you interpret your results ? **(2 marks)**
16.
 - a) Compare the ease with which the first hydrogen ion (proton) is removed from a diprotic acid in relation to the ease of removal of the second hydrogen ion. **(1 mark)**
 - b) Use an example from the table of acids to illustrate the above situation. **(1 mark)**
17. The weak acid, HClO, has a K_a of 3.24×10^{-8} . Calculate the pH of a 0.076 M solution of HClO. **(3 marks)**

ACID/BASE REVIEW

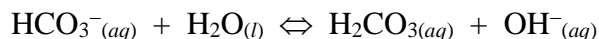
18. A solution with a pH of 4.20 is found to contain twice as much conjugate base as acid. Calculate the value of the acid dissociation constant (K_a) for this monoprotic acid. **(3 marks)**
19. Identify each substance in the following equation as either an acid or a base, and then state whether the position of equilibrium favours the reactants or products. **(3 marks)**



20. Calculate the pH of a 0.40 M solution of benzoic acid, $\text{C}_6\text{H}_5\text{COOH}$. K_a for $\text{C}_6\text{H}_5\text{COOH}$ is 6.6×10^{-5} . **(3 marks)**
21. 25.0 mL of 0.025 M $\text{Ca}(\text{OH})_2$ is completely neutralized by 28.3 mL of HCl solution. What is the concentration of the HCl solution? **(3 marks)**

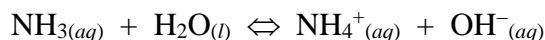


22. a) Write the equation for the acid-base equilibrium reaction that occurs when aqueous solutions containing equal concentrations of HCO_3^- and SO_3^{2-} are mixed. **(2 marks)**
b) What acid in the above equilibrium will be present in the greatest concentration? **(1 mark)**
25. a) Write the balanced molecular (formula) equation for the reaction between solution of NaOH and H_2SO_4 . **(1 mark)**
b) Write the net ionic equation for the above reaction. **(1 mark)**
26. Write an equation that shows HClO_2 acting as a weak acid in water. **(2 marks)**
27. Calculate the pH of a 0.70 M solution of boric acid, H_3BO_3 . Include the ionization equation of H_3BO_3 as part of your answer. **(4 marks)**
28. The hydrogen carbonate ion ionizes as a weak base according to the following equation:



Calculate the value of K_b for HCO_3^- . **(1 mark)**

29. Calculate the volume of 0.185 M HCl necessary to neutralize 2.36 g of $\text{Ba}(\text{OH})_2$. **(3 marks)**
30. Define the term “amphiprotic” and give an example of a chemical species that is amphiprotic. **(2 marks)**
31. Write the net ionic equation for the hydrolysis reaction that occurs when $\text{Be}(\text{CH}_3\text{COO})_2$ is dissolved in water. **(2 marks)**
33. Ammonia, a weak base, establishes the following equilibrium in water:



Calculate the $[\text{OH}^-]$ in a 1.0 M solution of NH_3 . **(4 marks) 91-6 #10**

ANSWERS

MULTIPLE CHOICE:

- | | | |
|-------|-------|--------|
| 1. C | 39. C | 76. B |
| 2. D | 40. D | 77. C |
| 3. C | 41. B | 78. A |
| 4. D | 42. A | 79. C |
| 5. B | 43. B | 80. A |
| 6. C | 44. D | 81. D |
| 7. C | 45. D | 82. A |
| 8. A | 46. C | 83. B |
| 9. D | 47. D | 84. C |
| 10. B | 48. B | 85. A |
| 11. A | 49. C | 86. D |
| 12. C | 50. A | 87. C |
| 13. B | 51. B | 88. B |
| 14. C | 52. D | 89. C |
| 15. C | 53. C | 90. A |
| 16. C | 54. A | 91. A |
| 17. B | 55. C | 92. B |
| 18. A | 56. A | 93. A |
| 19. C | 57. C | 94. D |
| 20. B | 58. A | 95. C |
| 21. A | 59. B | 96. B |
| 22. C | 60. A | 97. C |
| 23. B | 61. D | 98. C |
| 24. C | 62. A | 99. C |
| 25. A | 63. D | 100. B |
| 26. A | 64. C | 101. D |
| 27. D | 65. C | 102. D |
| 28. A | 66. C | 103. C |
| 29. A | 67. B | 104. A |
| 30. D | 68. A | 105. A |
| 31. A | 69. B | 106. B |
| 32. B | 70. B | 107. C |
| 33. C | 71. C | 108. D |
| 34. A | 72. A | 109. A |
| 35. A | 73. C | 111. B |
| 36. B | 74. A | 112. B |
| 37. C | 75. D | 113. A |
| 38. B | 75. D | 114. D |

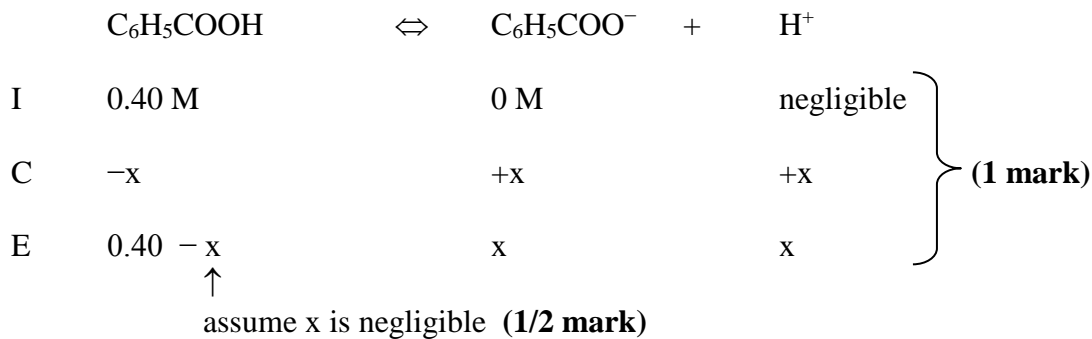
ANSWERS

WRITTEN RESPONSE:

- 1.5×10^{-5}
- $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- 3.0×10^{-8}
- 13.44
- $\text{HS}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{S}(\text{aq}) + \text{OH}^-(\text{aq})$
reactants
- basic because $K_b > K_a$
- 0.76 grams
- to prevent rapid changes in pH due to addition of H^+ or OH^- ions.
- $$\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$$

$$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$$

$$\text{SO}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$$
- 4.2×10^{-9}
- $7.2 \times 10^{-11} \text{ M}$
- $\text{Al}(\text{OH})_3$ or $\text{Al}(\text{H}_2\text{O})_3(\text{OH})_3$
 - NaOH
- $4.0 \times 10^{-2} \text{ M}$
- Use a pH indicator or meter. A lower pH indicates a higher $[\text{H}^+]$ which means greater dissociation which means stronger acid.
- 60 g/mol
- It's much easier to remove first proton.
 - $\text{H}_2\text{SO}_4 \rightarrow \text{H}^+ + \text{HSO}_4^-$ K_a very large
 $\text{HSO}_4^- \rightarrow \text{H}^+ + \text{SO}_4^{2-}$ K_a not as large
- 4.30
- 1.3×10^{-4}
- base, acid, acid, base
reactants

20. **answer: 2.29**

$$K_a = \frac{[\text{C}_6\text{H}_5\text{COO}^-][\text{H}^+]}{[\text{C}_6\text{H}_5\text{COOH}]} \quad (1/2 \text{ mark})$$

$$6.6 \times 10^{-5} = \frac{x^2}{0.40} \quad (1/2 \text{ mark})$$

$$x^2 = 2.64 \times 10^{-5}$$

$$x = \sqrt{2.64 \times 10^{-5}}$$

$$x = 5.1 \times 10^{-3} = [\text{H}^+] \quad (1/2 \text{ mark})$$

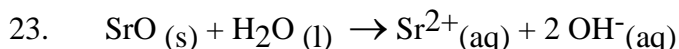
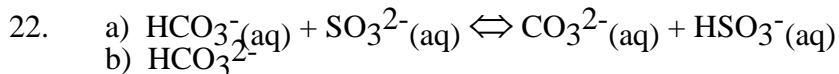
$$\text{pH} = -\log[\text{H}^+] = -\log(5.1 \times 10^{-3}) = 2.29 \quad (1 \text{ mark; subtract } 1/2 \text{ for incorrect sig figs})$$

21. **answer: 0.044 M**

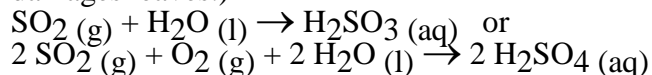
$$\text{mol Ca}^{2+} = 0.025 \text{ mL} \times \frac{0.025 \text{ mol}}{\text{L}} = 6.25 \times 10^{-4} \text{ mol} \quad (1 \text{ mark})$$

$$\text{mol H}^+ = 6.25 \times 10^{-4} \text{ mol Ca}^{2+} \times \frac{2 \text{ mol HCl}}{1 \text{ mol Ca(OH)}_2} = 1.25 \times 10^{-3} \text{ mol} \quad (1 \text{ mark})$$

$$[\text{HCl}] = [\text{H}^+] = \frac{1.25 \times 10^{-3} \text{ mol}}{0.0283 \text{ L}} = 0.0442 \text{ M} = 0.044 \text{ M} \quad (1 \text{ mark})$$



24. SO_2 produces acid rain. This acidifies lakes which kills fish. (It also destroys plant roots and damages leaves.)



$$29. \quad \text{moles Ba(OH)}_2 \text{ used} = 2.36 \text{ g} \times \frac{1 \text{ mol}}{171.3 \text{ g}} \quad (1/2 \text{ mark})$$

$$= 1.38 \times 10^{-2} \text{ mol} \quad (1/2 \text{ mark})$$

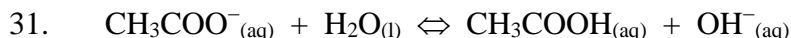
$$\text{moles HCl required} = 1.38 \times 10^{-2} \text{ mol Ba(OH)}_2 \times \frac{2 \text{ HCl}}{1 \text{ Ba(OH)}_2}$$

$$= 2.76 \times 10^{-2} \text{ mol} \quad (1 \text{ mark})$$

$$\text{volume HCl required} = 2.76 \times 10^{-2} \text{ mol} \times \frac{1 \text{ L}}{0.185 \text{ mol}}$$

$$= 0.149 \text{ L (or 149 mL)} \quad (1 \text{ mark})$$

30. A substance that is capable of accepting or donating a proton.
or A substance capable of acting as an acid or a base.

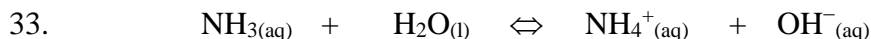


(1/2 mark for each chemical species above)

(If balanced molecular equation is given one mark awarded.)

32. To the KF solution add the conjugate acid of F^- , namely HF } (1 mark)
or Add any weak acid

$\text{HF}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{H}_3\text{O}^+_{(\text{aq})} + \text{F}^-_{(\text{aq})}$ }
or $\text{F}^-_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{HF}_{(\text{aq})} + \text{OH}^-_{(\text{aq})}$ } (1 mark)
or an appropriate balanced equation using a different weak acid.



I 1.0 M ---- 0 negligible

C -x +x +x

E 1.0 -x x x

↑

assume x is insignificant

$$K_b = \frac{K_w}{K_a(\text{NH}_4^+)} = \frac{1.00 \times 10^{-14}}{5.7 \times 10^{-10}} = 1.8 \times 10^{-5} \quad (1 \text{ mark})$$

$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = \frac{x^2}{1.0} = 1.8 \times 10^{-5} \quad (1/2 \text{ mark})$$

↑

(1/2 mark)

$$x = [\text{OH}^-] = 4.2 \times 10^{-3} \text{ M} \quad (1/2 \text{ mark})$$