ACID/BASE REVIEW

MULTIPLE CHOICE:

1. In the following equation,

$$HF + NO_2^- \Leftrightarrow HNO_2 + F^-$$

the HF is a Brönsted-Lowry

A. acid accepting protons
B. base accepting protons
C. acid donating protons
D. base donating protons

2. The conjugate base of $HSO_3^-{}_{(aq)}$ is

A. $H_2SO_{3(aq)}$
B. $HSO_3OH_{(l)}$
C. $SO_{3(g)}$
D. $SO_3^{2-}{}_{(aq)}$

3. In the following equation

$$N_2H_4 + (CH_3)_3HN^+ \Leftrightarrow N_2H_5^+ + (CH_3)_3N$$

a conjugate acid-base pair is

A. N_2H_4 and $(CH_3)_3NH^+$
B. N_2H_4 and $(CH_3)_3N$
C. $N_2H_5^+$ and N_2H_4
D. $(CH_3)_3NH^+$ and $N_2H_5^+$

4. In the equation

$$ClO_4^- + HNO_3 \rightarrow HClO_4 + NO_3^-$$

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

A. acid + base $\Leftrightarrow$ base + acid
B. acid + base $\Leftrightarrow$ acid + base
C. base + acid $\Leftrightarrow$ base + acid
D. base + acid $\Leftrightarrow$ acid + base

5. The equation showing the acid form of an indicator reacting with a basic solution is

A. $In^-{}_{(aq)} + OH^-{}_{(aq)} \Leftrightarrow HIn_{(aq)}$
B. $HIn_{(aq)} + OH^-{}_{(aq)} \Leftrightarrow H_2O_{(l)} + In^-{}_{(aq)}$
C. $In^-{}_{(aq)} + H_3O^+{}_{(aq)} \Leftrightarrow HIn_{(aq)} + H_2O_{(aq)}$
D. $HIn_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+{}_{(aq)} + In^-{}_{(aq)}$

6. Note the following reactions involving water

$$H_2O_{(l)} + HBr_{(aq)} \Leftrightarrow H_3O^+_{(aq)} + Br^-_{(aq)}$$

$$H_2O_{(l)} + CN^-_{(aq)} \Leftrightarrow HCN_{(aq)} + OH^-_{(aq)}$$

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 $[H_3O^+]$ 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:

$$HPO_4^{2-}_{(aq)} + NH_4^+_{(aq)} \Leftrightarrow H_2PO_4^-_{(aq)} + NH_{3(aq)}$$

the strongest acid in the above equation is

A. NH_4^+
B. HPO_4^{2-}
C. NH_3
D. $H_2PO_4^-$

10. Which of the following gases will give the most basic solution on dissolving in water?

A. $H_2S_{(g)}$
B. $NH_{3(g)}$
C. $CO_{2(g)}$
D. $SO_{2(g)}$

11. A formula for a salt is

    A. Na_2HPO_4
    B. H_3PO_4
    C. C_6H_5COOH
    D. $Cu(NH_3)_4^{2+}$

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. $Na_2CO_{3(s)} + H_2O_{(l)} \Leftrightarrow Na_2O_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

    B. $CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \Leftrightarrow HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

    C. $Na_2CO_{3(s)} \rightarrow 2Na^+{}_{(aq)} + CO_3^{2-}{}_{(aq)}$

    D. $Na_2CO_{3(s)} + H_2O_{(l)} \Leftrightarrow Na_2CO_{4(aq)} + H_{2(g)}$

14. Which of the expressions given below illustrates a correct expression for pH?

    A. $\log [H_3O^+]$
    B. $-\log [H_3O^+]^2$
    C. $-\log [H_3O^+]$
    D. $-\log (1/[H_3O^+])$

15. What is the hydronium ion concentration, $[H_3O^+]$, of a 0.00100 M sodium hydroxide (NaOH) solution?

    A. 1.00×10^{-3} M
    B. 11.0 M
    C. 1.00×10^{-11} 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

17. The $[H_3O^+]$ 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}

18. Which of the following equations represents an acid-base titration?

I. $Na^+_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow H_2O_{(l)} + Na^+_{(aq)} + Cl^-_{(aq)}$

II. $CH_3COOH_{(l)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

III. $3Cu_{(s)} + 2NO_3^-{}_{(aq)} + 8H^+_{(aq)} \rightarrow 3Cu^{2-}_{(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$

IV. $Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$

A. I
B. II
C. III
D. IV

19. 100 mL of a 0.100 M NaOH solution are titrated with 200 mL of a 0.0500 M HCl solution. The approximate pH of the resulting solution is

A. 5.00
B. 6.00
C. 7.00
D. 8.00

20. During a titration reaction 80.0 mL of a 0.100 M HCl solution are added to 100.0 mL of a 0.100 M NaOH solution. The $[OH^-]$ of the resulting solution is

A. 11.1 M
B. 1.11×10^{-2}
C. 11.11×10^{-1} M
D. 1.11×10^{2} M

21. Given that $K_b = \frac{[NH_3][OH^-]}{[NH_4^+]}$ $K_a = \frac{[NH_4^+][H_3O^+]}{[NH_3]}$

and $K_w = [H_3O^+][OH^-]$

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, $C_6H_5NH_2$, is in equilibrium with its conjugate acid, $C_6H_5NH_3^+$. If the numerical value of K_b for aniline is 4.30×10^{-10}, the value of K_a for its conjugate acid $C_6H_5NH_3$ 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

24. Given that

$$NH_{3(aq)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH_{(aq)} \qquad K_b\,(NH_3) = 1.8 \times 10^{-5}$$

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

25. Which one of the following equations contains a conjugate acid-base pair from which a buffer solution can be prepared?

A. $HCN_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + CN^-_{(aq)}$
B. $HCl_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$
C. $HNO_{3(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + NO_3^-_{(aq)}$
D. $HClO_{4(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + ClO_4^-_{(aq)}$

26. Which one of the following equations contains a conjugate acid-base pair from which a buffer solution can be prepared?

A. $CH_3COOH + H_2O \Leftrightarrow H_3O^+ + CH_3COO^-$
B. $H_2SO_4 + H_2O \Leftrightarrow H_3O^+ + SO_4^{2-}$
C. $HBr + H_2O \Leftrightarrow H_3O^+ + Br^-$
D. $HI + H_2O \Leftrightarrow H_3O^+ + I^-$

27. In the equation $NH_4^+ + H_2O \Leftrightarrow H_3O^+ + NH_3$, how does the H_2O act?

A. As a Brönsted-Lowry acid donating protons.
B. As a Brönsted-Lowry acid accepting protons.
C. As a Brönsted-Lowry base donating protons.
D. As a Brönsted-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 Brönsted acids or bases in the equation

$$HSO_3^- + HPO_4^- \Leftrightarrow H_2PO_4^- + SO_3^{2-}$$

A. acid + base $\Leftrightarrow$ acid + base
B. acid + base $\Leftrightarrow$ base + acid
C. base + acid $\Leftrightarrow$ acid + base
D. base + acid $\Leftrightarrow$ 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

31. Which one of the following equation shows the basic form of an indicator HIn reacting in an acidic solution?

A. $In^-_{(aq)} + H_3O^+_{(aq)} \Leftrightarrow HIn_{(aq)} + H_2O_{(l)}$

B. $HIn_{(aq)} + H_3O^+_{(aq)} \Leftrightarrow H_2In^+_{(aq)} + H_2O_{(l)}$

C. $In^-_{(aq)} + H_2O_{(l)} \Leftrightarrow HIn_{(aq)} + OH^-_{(aq)}$

D. $HIn_{(aq)} + OH^-_{(aq)} \Leftrightarrow In^-_{(aq)} + H_2O_{(l)}$

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 $[H_3O^+]$ 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.

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 titrated with 200.0 mL of a 0.025 M solution of HCl?

A. 6.00
B. 7.00
C. 8.0
D. 9.00

39. During the titration of 50.0 mL of a 0.200 M KOH solution with 0.200 M HNO_3, 20.0 mL of the HNO_3 is added. What is the pH at this point of the titration?

A. 0.92.
B. 1.07
C. 12.93
D. 13.08

40. In which of the following buffer solutions will addition of H_3O^+ cause the equilibrium to shift to the left?

I. $HF + H_2O \Leftrightarrow H_3O^+ + F^-$

II. $H_2PO_4^- + H_3O^+ \Leftrightarrow H_3PO_4 + H_2O$

III. $HPO_4^{2-} + OH^- \Leftrightarrow PO_4^{3-} + H_2O$

IV. $HSO_3^- + OH^- \Leftrightarrow SO_3^{2-} + H_2O$

A. I only.
B. II only.
C. III and IV only
D. I, III and IV.

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

$HNO_{2(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + NO_2^-{}_{(aq)}$

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

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}

43. Which one of the following statements explains why oxalic acid, $H_2C_2O_4 \cdot 2H_2O$, is useful as a primary standard in acid-base titrations?

A. It contains two replaceable hydrogen ions.
B. It can be obtained very pure, and is a crystalline solid.
C. It has a large K_a and so gives better results in titrations.
D. A stoichiometric point of its titrations is on the basic side of neutral pH 7, which is better for titrations involving strong bases.

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

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

45. Which one of the following equations contains the conjugate acid-base pair from which a buffer solution can be prepared?

A. $HI_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + I^-_{(aq)}$

B. $HBr_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + Br^-_{(aq)}$

C. $H_2SO_{4(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$

D. $H_2CO_{3(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$

46. Which one of the following equations could represent a titration reaction?

A. $CH_3COOH_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$
B. $2HBr_{(aq)} + Cl_{2(g)} \rightarrow 2HCl_{(aq)} + Br_{2(aq)}$
C. $KHCO_{3(aq)} + HBr_{(aq)} \rightarrow KBr_{(aq)} + H_2O_{(l)} + CO_{2(g)}$
D. $3Zn_{(s)} + 2NO_{2(aq)} + 3H^+_{(aq)} \rightarrow 3Zn^{2+}_{(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$

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

$$CH_3COOH_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$

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

A. $K_a = [H_3O^+][CH_3COO^-]$

B. $K_a = \dfrac{[H_3O^+][CH_3COO^-]}{[H_2O][CH_3COOH]}$

C. $K_a = \dfrac{[CH_3COOH][H_3O^+]}{[CH_3COO^-]}$

D. $K_a = \dfrac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$

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

$$H_2O_{2(aq)} + H_2O_{(l)} \Leftrightarrow HO_2^-{}_{(aq)} + H_3O^+_{(aq)} \ ?$$

A. $HO_2^-{}_{(aq)}$
B. $H_2O_{(l)}$
C. $H_2O_{2(aq)}$
D. $H_3O^+_{(aq)}$

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

$$C_6H_5NH_{2(aq)} + H_2O_{(l)} \Leftrightarrow C_6H_5NH^+_{(aq)} + OH^-_{(aq)} \ ?$$

A. acid + base $\Leftrightarrow$ acid + base
B. acid + base $\Leftrightarrow$ base + acid
C. base + acid $\Leftrightarrow$ acid + base
D. base + acid $\Leftrightarrow$ base + acid

50. Which one of the following statements **BEST** describes a Brönsted-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

$$H_2S_{(aq)} + H_2O_{(l)} \Leftrightarrow HS^-_{(aq)} + H_3O^+_{(aq)}$$

A. $K_a = \dfrac{[HS^-][H_3O^+]}{[H_2S][H_2O]}$

B. $K_a = \dfrac{[H_2S][H_2O]}{[HS^-][H_3O^+]}$

C. $K_a = \dfrac{[H_2S]}{[HS^-][H_3O^+]}$

D. $K_a = \dfrac{[HS^-][H_3O^+]}{[H_2S]}$

53. Which one of the following expression is the correct expression for pK_w?

A. $pK_w = \dfrac{1}{K_w}$
B. $pK_w = (pH)(pOH)$
C. $pK_w = pH + pOH$
D. $pK_w =$ 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 Ka for $N_2H_5^+$?

A. 5.88×10^{-9}
B. 1.70×10^{-6}
C. 5.88×10^{5}
D. 1.70×10^{8}

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

$$2H_2O_{(l)} + 57.3\ kJ \Leftrightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$$

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 (C_6H_5COOH) ?

A. 1.94
B. 2.24
C. 3.88
D. 4.48

57. A dilute solution of Na_2S will contain

A. undissociated Na_2S
B. more $HS^-_{(aq)}$ than $S^{2-}_{(aq)}$
C. more $H_3O^+_{(aq)}$ than $OH^-_{(aq)}$
D. strongly hydrolyzed $Na^+_{(aq)}$

58. When selecting an indicator for any titration, how should the indicator endpoint compare to the titration stoichiometric point?

A. The endpoint and stoichiometric point should coincide.
B. The endpoint should be before the stoichiometric point.
C. The endpoint should be after the stoichiometric point.
D. The endpoint and stoichiometric point should both be at pH 9.

59. Which one of the following describes the pH at the stoichiometric point in the titration of a strong acid with a strong base?

A. pH = 0
B. pH = 7
C. 0 < pH < 7
D. 7 < pH < 14

60. 30.0 mL of 0.50 M HCl solution are titrated with 20.0 mL of 0.50 M NaOH solution. What is the pH of the resulting solution?

A. 0.00
B. 1.00
C. 7.00
D. 13.00

61. Which of the following equations represents an acid-base titration?

A. $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \Leftrightarrow BaSO_{4(s)}$

B. $CH_3COOK_{(s)} + H_2O_{(l)} \Leftrightarrow K^+_{(aq)} + CH_3COO^-_{(aq)}$

C. $Zn_{(s)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \Leftrightarrow Zn^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + H_{2(g)}$

D. $K^+_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + NO_3^-{}_{(aq)} \Leftrightarrow H_2O_{(l)} + K^+_{(aq)} + NO_3^-{}_{(aq)}$

62. In a titration, 20.0 mL of 0.50 M NaOH solution reacts completely with 30.0 mL of H_2SO_4 solution. What is the initial concentration of the H_2SO_4 solution?

A. 0.17 M
B. 0.33 M
C. 0.50 M
D. 0.67 M

63. An acid buffer is a solution containing

A. a strong acid and its salt.
B. a strong acid and a strong base.
C. a weak acid and a strong acid.
D. a weak acid and a salt of its conjugate base.

64. Which one of the following will occur when $NaF_{(s)}$ 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 $Al(H_2O)_6^{3+}{}_{(aq)}$?

A. $Al(H_3O)_6^{4+}{}_{(aq)}$

B. $Al(H_2O)_6^{2+}{}_{(aq)}$

C. $Al(H_2O)_5OH^{2+}{}_{(aq)}$

D. $Al(H_2O)_6OH^{2+}{}_{(aq)}$

66. Which of the following solutions will have the greatest $[H_3O^+]$

A. 0.05 M HNO_2
B. 0.10 M HCl
C. 0.15 M HNO_3
D. 0.20 M HCN

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

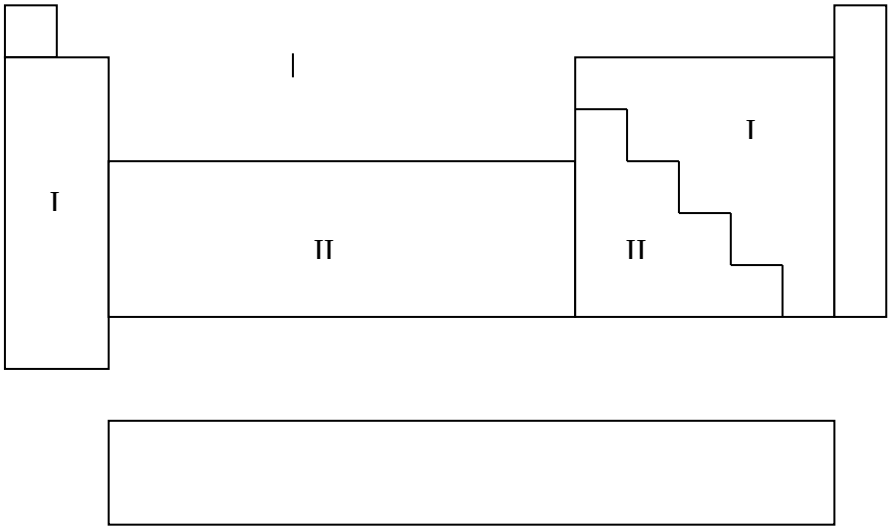
A. $2HSO_3^-{}_{(aq)} \rightarrow S_2O_5^{2-}{}_{(aq)} + H_2O_{(l)}$

B. $HSO_3^-{}_{(aq)} + H_3O^+{}_{(aq)} \rightarrow H_2SO_{3(aq)} + H_2O_{(l)}$

C. $HSO_3^-{}_{(aq)} + OH^-{}_{(aq)} \rightarrow SO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

D. $HSO_3^-{}_{(aq)} + HPO_4^{2-}{}_{(aq)} \rightarrow SO_3^{2-}{}_{(aq)} + H_2PO_4^-{}_{(aq)}$

Use the following table to answer question 68.



68. In which area of the periodic table shown would you find elements which form the most basic oxides?

A. I
B. II
C. III
D. IV

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

$$NH_{3(aq)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

The K_b expression for this reaction is

A. $\dfrac{[NH_3]}{[NH_4^+][OH^-]}$

B. $\dfrac{[NH_4^+][OH^-]}{[NH_3]}$

C. $\dfrac{[NH_4^+][OH^-]}{[NH_3][H_2O]}$

D. $\dfrac{[NH_3][H_2O]}{[NH_4^+][OH^-]}$

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.

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 $[H_3O^+]$ in a solution with $[OH^-] = 2.7 \times 10^{-4}$ M?

A. 3.7×10^{-11} M
B. 7.3×10^{-8} M
C. 2.7×10^{-4} M
D. 3.7×10^{-4} M

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

$$NH_{3(aq)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

A. 2.7×10^{-6} M
B. 1.2×10^{-4} M
C. 1.7×10^{-3} M
D. 4.2×10^{-3} 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?

$$Ba(OH)_{2(aq)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2H_2O_{(l)}$$

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

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

A. 5.00×10^{-2} L
B. 1.00×10^{-1} L
C. 2.00×10^{-1} L
D. 5.00×10^{-1} 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

80. When methyl red ($K_a = 1.0 \times 10^{-5}$) is used as an indicator in a titration, it will change colour at a pH of approximately

A. 5
B. 7
C. 9
D. 10

81. Which of the following combinations will make a buffer solution?

A. HNO_3 and NO_3^-
B. H_2SO_4 and HSO_4^-
C. $HClO_4$ and ClO_4^-
D. CH_3COOH and CH_3COO^-

82. Which of the following equations represents the buffer equilibrium present in an aqueous solution containing NH_3 and NH_4Cl?

A. $NH_{3(aq)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$
B. $H_3O^+{}_{(aq)} + OH^-{}_{(aq)} \Leftrightarrow 2H_2O_{(l)}$
C. $NH_4^+{}_{(aq)} + Cl^-{}_{(aq)} \Leftrightarrow NH_4Cl_{(s)}$
D. $NH_{3(aq)} + Cl^-{}_{(aq)} \Leftrightarrow NH_2^-{}_{(aq)} + HCl_{(aq)}$

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 Brönsted-Lowry acids in the following equilibrium?

$$O^{2-} + HSO_4^- \Leftrightarrow OH^- + SO_4^{2-}$$

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:

$$HPr + H_2O \Leftrightarrow H_3O^+ + Pr^-$$

If NaOH is added, this equilibrium shifts to the

A. left as [HPr] decreases.
B. right as [HPr] increases.
C. left as $[H_3O^+]$ increases.
D. right as $[H_3O^+]$ decreases.

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

A. $HF + HS^- \Leftrightarrow F^- + H_2S$

B. $HF + OH^- \Leftrightarrow F^- + H_2O$

C. $HF + SO_4^{2-} \Leftrightarrow F^- + HSO_4^-$

D. $HF + CH_3COO^- \Leftrightarrow F^- + CH_3COOH$

88. The expression for the ionization constant of water is

A. $K_w = \dfrac{[H_3O^+]}{[OH^-]}$

B. $K_w = [H_3O^+][OH^-]$

C. $K_w = \dfrac{[H_3O^+][OH^-]}{[H_2O]}$

D. $K_w = [H_3O^+] + [OH^-]$

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

A. acidic with $[H_3O^+] = 3.1 \times 10^{-7}$ M.

B. acidic with $[H_3O^+] = 1.8 \times 10^{-7}$ M.

C. neutral with $[H_3O^+] = 1.8 \times 10^{-7}$ M.

D. neutral with $[H_3O^+] = 1.0 \times 10^{-7}$ M.

90. In a solution at 25°C where $[H_3O^+]$ = b2.0 M, the $[OH^-]$ 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:

$$K_{eq} = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$$

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^-

92. The net ionic equation for the hydrolysis that occurs when KF is dissolved in water is

A. $KF_{(s)} \rightarrow K^+_{(aq)} + F^-_{(aq)}$
B. $F^-_{(aq)} + H_2O_{(l)} \Leftrightarrow HF_{(aq)} + OH^-_{(aq)}$
C. $KF_{(s)} + H_2O_{(l)} \Leftrightarrow HKF^+_{(aq)} + OH^-_{(aq)}$
D. $KF_{(s)} + H_2O_{(l)} \rightarrow HF_{(aq)} + KOH_{(aq)}$

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 $[H_3O^+]$ 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

97. In a solution of pH 9.52, the $[OH^-]$ is

A. 3.0×10^{-10} M
B. 1.7×10^{-5} M
C. 3.3×10^{-5} 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:

$$SO_4^{2-} + HNO_2 \Leftrightarrow HSO_4^- + NO_2^-$$

Equilibrium would favour

A. the products since HSO_4^- is a weaker acid that HNO_2.
B. the reactants since HSO_4^- is a weaker acid that 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^-

103. Which of the following acids will have the greatest $[OH^-]$?

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. 6.7×110^{-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 $[H_3O^+]$ at various temperatures giving the following data:

Temperature (°C)	0	20	40	60
$[H_3O^+]$	4.4×10^{-8} M	8.2×10^{-8} M	1.3×10^{-7} M	3.2×10^{-7} 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. $[H_3O^+]$ increases while $[OH^-]$ decreases.

108. 25.00 mL of a solution of HCl was titrated with 0.4500 M NaOH using bromthymol blue as indicator. Successive readings of the burette gave the following data:

Volume of NaOH (mL)	**Colour**
16.35	yellow
16.40	yellow
16.45	green
16.50	blue

Based on these data, the original [HCl] was

A. 0.06839 M
B. 0.2948 M
C. 0.2957 M
D. 0.2970 M

109. Which of the following oxides, when dissolved in water, will produce the most basic solution?

A. SO_2
B. CO_2
C. BaO
D. ClO

110. In comparison with a strong acid – weak base titration, the equivalence point of a strong acid – strong base titration

A. occurs at a higher pH.
B. is more difficult to detect.
C. gives more reliable results.
D. occurs within a narrower pH range.

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

$$HInd_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + Ind^-_{(aq)}$$

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. [HInd] = [HCl]
B. [HInd] = [Ind^-]
C. [HInd] = [H_3O^+]
D. [HInd] = K_a[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 :

   $HPO_4^{2-}_{(aq)}$ $K_a = 4.4 \times 10^{-13}$
   $HPO_4^{2-}_{(aq)}$ $K_b = 1.6 \times 10^{-7}$

   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 to10.0 mL of a 2.00 M HNO_3 solution to obtain a pH of 1.00. **(4 marks)**

8. What is the function of a buffer in a chemical system ? **(1 mark)**

9. Combustion of coal which contains sulphur produces a gaseous sulphur compound. This compound, when released into the atmosphere, undergoes a series of reactions eventually forming "acid rain". Explain this process, and support your answer with appropriate equations. **(3 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 amphiprotic 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)**

15. In an acid-base titration, it was found that 18.4 mL of 0.200 M NaOH was required to neutralize a 0.22 g sample of a monoprotic acid. What is the mass of one mole of this acid ? **(3 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)**

18. A solution with a pH of 4.20 is found to contain twice as much conjugate base as acid. alculate 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 hether the position of equilibrium favours the reactants or products. **(3 marks)**

$$HOOCCOO^-_{(aq)} + H_2PO_4^-(aq) \Leftrightarrow HOOCCOOH_{(aq)} + HPO_4^{2-}(aq)$$

20. Calculate the pH of a 0.40 M solution of benzoic acid, C_6H_5COOH. K_a for C_6H_5COOH is 6.6×10^{-5}. **(3 marks)**

21. 25.0 mL of 0.025 M $Ca(OH)_2$ is completely neutralized by 28.3 mL of HCl solution. What is the concentration of the HCl solution ? **(3 marks)**

$$Ca(OH)_2 + 2\ HCl \rightarrow CaCl_2 + 2\ H_2O$$

22. a) Write the equation for the acid-base equilibrium reaction that occurs when aqueous solutions containing equal concentrationsof 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)**

23. Write a balanced equation showing the formation of a basic aqueous solution using the metal xide SrO. **(1 mark)**

24. SO_2 is a waste product in some industrial processes. State the environmental problem ssociated with $SO_{2\ (g)}$, write the equation that accounts for this problem, and give one effect on the natural environment. **(2 marks)**

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:

$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \Leftrightarrow H_2CO_{3(aq)} + OH^-{}_{(aq)}$$

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 $Ba(OH)_2$. **(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 $Be(CH_3COO)_2$ is dissolved in water. **(2 marks)**

32. Using KF as one of the reagents, describe how to prepare a buffer solution. Write the equation of the equilibrium present in this buffer, and state the purpose of a buffer solution. **(3 marks)**

33. Ammonia, a weak base, establishes the following equilibrium in water:

$$NH_{3(aq)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

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

ANSWERS

MULTIPLE CHOICE:

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

ANSWERS

WRITTEN RESPONSE:

1. 1.5×10^{-5}

2. $H^+(aq) + OH^-(aq) \rightarrow H_2O\ (l)$

3. 3.0×10^{-8}

4. 13.44

5. $HS^-(aq) + H_2O\ (l) \Leftrightarrow H_2S\ (aq) + OH^-\ (aq)$
   reactants

6. basic because $K_b > K_a$

7. 0.76 grams

8. to prevent rapid changes in pH due to addition of H^+ or OH^- ions.

9. $S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$
   $2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$
   $SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (l)$

10. 4.2×10^{-9}

11. 7.2×10^{-11} M

12. a) $Al(OH)_3$ or $Al(H_2O)_3(OH)_3$
    b) NaOH

13. 4.0×10^{-2} M

14. Use a pH indicator or meter. A lower pH indicates a higher $[H^+]$ which means greater dissociation which means stronger acid.

15. 60 g/mol

16. a) It's much easier to remove first proton.
    b) $H_2SO_4 \rightarrow H^+ + HSO_4^-$ K_a very large
    $HSO_4^- \rightarrow H^+ + SO_4^{2-}$ K_a not as large

17. 4.30

18. 1.3×10^{-4}

19. base, acid, acid, base
    reactants

20. **answer: 2.29**

	C_6H_5COOH	$\Leftrightarrow$	$C_6H_5COO^-$	+	H^+	
I	0.40 M		0 M		negligible	**(1 mark)**
C	−x		+x		+x	
E	0.40 − x ↑ assume x is negligible **(1/2 mark)**		x		x	

$K_a = \dfrac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]}$ **(1/2 mark)**

$6.6 \times 10^{-5} = \dfrac{x^2}{0.40}$ **(1/2 mark)**

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

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

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

$pH = -\log[H^+] = -\log(5.1 \times 10^{-3}) =$ 2.29 **(1 mark; subtract ½ for incorrect sig figs)**

21. **answer: 0.044 M**

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

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

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

22. a) $HCO_3^-(aq) + SO_3^{2-}(aq) \Leftrightarrow CO_3^{2-}(aq) + HSO_3^-(aq)$
b) HCO_3^{2-}

23. $SrO\ (s) + H_2O\ (l) \rightarrow Sr^{2+}(aq) + 2\ OH^-(aq)$

24. SO_2 produces acid rain. This acidifies lakes which kills fish. (It also destroys plant roots and damages leaves.)
$SO_2\ (g) + H_2O\ (l) \rightarrow H_2SO_3\ (aq)$ or
$2\ SO_2\ (g) + O_2\ (g) + 2\ H_2O\ (l) \rightarrow 2\ H_2SO_4\ (aq)$

25. a) $2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2H_2O_{(l)} + Na_2SO_{4(aq)}$
b) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

26. $HClO_2 + H_2O \Leftrightarrow H_3O^+ + ClO_2^-$ **1 mark for correct reactants and products**
1 mark for equilibrium

or $HClO_2 \Leftrightarrow H^+ + ClO_2^-$

27.

	$H_3BO_{3(aq)}$	$+ H_2O \rightarrow$	$H_3O^+_{(aq)}$	+ $H_2BO_3^-{}_{(aq)}$
I	0.70 M		negligible	0
C	−x		+x	+x
E	0.70 −x		+x	+x

(1 mark for ICE table)

↑
assume x << 0.70 **(1/2 mark)**

$$K_a = \frac{[H_3O^+][H_2BO_3^-]}{[H_3BO_3]}$$

$$K_a = 6.5 \times 10^{-10} = \frac{x^2}{0.70}$$ **(1/2 mark)**

$$x = \sqrt{(0.70)(6.5\times10^{-5})}$$

$x = [H_3O^+] = 2.1 \times 10^{-5}$ M **(1/2 mark)**

$pH = -\log[H_3O^+] = -\log(2.1 \times 10^{-5}) = 4.67$ **(1/2 mark)**
(1/2 mark for correct sig figs)

28. $$K_b\,(HCO_3^-) = \frac{K_w}{K_a(H_2CO_3)}$$

$$K_b\,(HCO_3^-) = \frac{1.00 \times 10^{-14}}{4.4 \times 10^{-7}}$$ **(1/2 mark)**

$= 2.3 \times 10^{-8}$ **(1/2 mark)**

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

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

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

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

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

$= 0.149$ L (or 149 mL) **(1 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.

31. $CH_3COO^-_{(aq)} + H_2O_{(l)} \Leftrightarrow CH_3COOH_{(aq)} + OH^-_{(aq)}$
(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

$HF_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + F^-_{(aq)}$
or $F^-_{(aq)} + H_2O_{(l)} \Leftrightarrow HF_{(aq)} + OH^-_{(aq)}$ **(1 mark)**
or an appropriate balanced equation using a different weak acid.

33.

	$NH_{3(aq)}$ +	$H_2O_{(l)}$ $\Leftrightarrow$	$NH_4^+{}_{(aq)}$ +	$OH^-_{(aq)}$
I	1.0 M	----	0	negligible
C	−x		+x	+x
E	1.0 −x ↑ assume x is insignificant		x	x

$K_b = \frac{K_w}{K_a(NH_4^+)} = \frac{1.00 \times 10^{-14}}{5.7 \times 10^{-10}} = 1.8 \times 10^{-5}$ **(1 mark)**

$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x^2}{1.0} = 1.8 \times 10^{-5}$ **(1/2 mark)**
↑ **(1/2 mark)**

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