1. Which of the following represents the dissociation of Na₂CO₃?
   A. Na₂CO₃(s) + 2 H₂O(l) → 2 Na⁺(aq) + 2 OH⁻(aq) + H₂CO₃(aq)
   B. Na₂CO₃(aq) → 2 Na⁺(aq) + CO₃²⁻(aq)
   C. Na₂CO₃(s) → Na⁺(aq) + NaCO₃(aq)
   D. Na₂CO₃(aq) + H₂O(l) → H₂CO₃ + Na₂O(aq)
   E. CO₃²⁻(aq) + H₂O(l) → HCO₃⁻ + OH⁻(aq)

2. Which of the following will have the greatest [H₃O⁺]?
   A. 0.10 M NaCH₃COO  B. 0.10 M NaF  C. 0.10 M NaIO₃  D. 0.10 M Na₂SO₃

3. The approximate pH of a 0.66 M solution of CH₃COOH is:
   A. 13  B. 1  C. 3  D. 11

4. The pH of 0.60 M HClO₄ is:
   A. 13.78  B. 0.60  C. 0.22  D. -0.60

5. The pH of 100 mL of 0.20 M NaOH is:
   A. 13.30  B. 0.70  C. 1.30  D. 12.30

6. The pH of a 0.13 M strontium hydroxide solution is:
   A. 13.41  B. 0.59  C. 0.89  D. 13.11

7. In a solution of pH 9.52, the [OH⁻] is:
   A. 1.7 × 10⁻⁵ M  B. 3.0 × 10⁻¹⁰ M  C. 4.48 M  D. 3.3 × 10⁻⁵ M

8. The [H₃O⁺] in 0.20 M NaOH is:
   A. 0.20 M  B. 5.0 × 10⁻¹⁴ M  C. 1.0 × 10⁻¹⁴ M  D. 2.0 × 10⁻¹⁵ M

9. Consider the following equilibrium constant expression:
   \[ K_{eq} = \frac{[HCO₃⁻][OH⁻]}{[CO₃²⁻]} \]

   This expression represents:
   A. \( K_a \) for HCO₃⁻  B. \( K_b \) for CO₃²⁻  C. \( K_a \) for CO₃²⁻  D. \( K_b \) for HCO₃⁻
10. Consider the following equilibrium constant expression.

\[
K_{eq} = \frac{[PO_4^{3-}] [H_3O^+]}{[HPO_4^{2-}]}
\]

This expression represents:
A. \( K_b \) for \( PO_4^{3-} \)  
B. \( K_b \) for \( H_2PO_4^- \)  
C. \( K_a \) for \( HPO_4^{2-} \)  
D. \( K_b \) for \( HPO_4^{2-} \)

11. The acid used in the lead-acid storage battery is:
A. \( CH_3COOH \)  
B. \( HCl \)  
C. \( HNO_3 \)  
D. \( H_2SO_4 \)

12. An acid which, in concentrated form reacts with copper, hence is used for etching copper, and turns skin yellow on contact is
A. sulphuric acid  
B. hydrochloric acid  
C. acetic acid  
D. nitric acid

13. A compound used in the production of soap is
A. acetic acid  
B. hypochlorous acid  
C. sodium hydroxide  
D. ammonia

14. In the following Bronsted-Lowry acid-base equation:

\[
NH_4^{+} (aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+ (aq)
\]

The stronger base is:
A. \( H_3O^+ \)  
B. \( NH_4^+ \)  
C. \( H_2O \)  
D. \( NH_3 \)

15. In which of the following equations is \( H_2O \) shown acting as a Brönsted-Lowry base?
A. \( Na_2CO_3(s) + H_2O(l) \rightleftharpoons Na_2CO_3 \cdot H_2O(s) \)
B. \( 2 Na(s) + 2 H_2O(l) \rightleftharpoons 2 Na^+(aq) + 2 OH^-(aq) + H_2(g) \)
C. \( CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq) \)
D. \( H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq) \)

16. Which two substances act as the Brönsted-Lowry acids in the following equilibrium?

\[
O^2- + HSO_4^- \rightleftharpoons OH^- + SO_4^{2-}
\]

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

17. Consider the following equilibrium system.

\[
HF + CH_3COO^- \rightleftharpoons F^- + CH_3COOH
\]

In the above equilibrium, \( CH_3COO^- \) acts as a:
A. Brönsted-Lowry acid accepting protons.  
B. Brönsted-Lowry acid donating protons.  
C. Brönsted-Lowry base donating protons.  
D. Brönsted-Lowry base accepting protons.

Version: 1
18. In the reaction:

\[ \text{NH}_4^+_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{NH}_3_{(aq)} \]

\( \text{NH}_4^+ \) is acting as a:

A. Brönsted-Lowry base donating protons.  
B. Brönsted-Lowry acid donating protons.  
C. Brönsted-Lowry base accepting protons.  
D. Brönsted-Lowry acid accepting protons.

19. In an experiment, a student is given a test tube known to contain one of the following:

\[ \text{NaOH}_{(aq)} , \quad \text{CH}_3\text{COOH}_{(aq)} , \quad \text{H}_2\text{O}_{(l)} , \quad \text{HNO}_3_{(aq)} \]

The student tests the sample, resulting in the following data:

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>litmus paper</td>
<td>turns blue litmus paper red</td>
</tr>
<tr>
<td>zinc metal</td>
<td>produces hydrogen gas</td>
</tr>
<tr>
<td>electrical conductivity</td>
<td>poor conductor</td>
</tr>
</tbody>
</table>

Based on the above data, the sample is:

A. CH$_3$COOH  
B. H$_2$O  
C. HNO$_3$  
D. NaOH

20. In the equilibrium system:

\[ \text{H}_2\text{BO}_3_{(aq)} + \text{HCO}_3_{(aq)} \rightleftharpoons \text{H}_2\text{CO}_3_{(aq)} + \text{HBO}_3^{2-}_{(aq)} \]

The two species acting as Bronsted-Lowry acids are:

A. H$_2$BO$_3^-$ and HBO$_3^{2-}$  
B. HCO$_3^-$ and H$_2$CO$_3$  
C. H$_2$BO$_3^-$ and H$_2$CO$_3$  
D. HCO$_3^-$ and HBO$_3^{2-}$

21. Consider the following equilibrium system:

\[ \text{HS}^- + \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}_2\text{S} + \text{HCO}_3^- \]

The two species acting as Brönsted-Lowry acids in the above equilibrium are:

A. H$_2$CO$_3$ and HCO$_3^-$  
B. HS$^-$ and H$_2$S  
C. HS$^-$ and H$_2$CO$_3$  
D. H$_2$CO$_3$ and H$_2$S

22. The [OH$^-$] is greater than the [H$_3$O$^+$] in:

A. CH$_3$COOH$_{(aq)}$  
B. H$_2$O$_{(aq)}$  
C. NH$_3_{(aq)}$  
D. HCl$_{(aq)}$

23. Which of the following salts contains an amphiprotic ion?

A. NaCH$_3$COO  
B. NaH$_2$PO$_4$  
C. Na$_2$O  
D. Na$_2$CO$_3$
24. The conjugate base of OH\(^-\) is:
   A. \(\text{H}_2\text{O}^+\)  
   B. \(\text{H}_2\text{O}\)  
   C. \(\text{O}^{2-}\)  
   D. \(\text{H}_2\)  

25. Which of the following statements describes how \(\text{H}_2\text{SO}_3\) and \(\text{HSO}_3^-\) are related?
   A. \(\text{H}_2\text{SO}_3\) and \(\text{HSO}_3^-\) are conjugate bases of each other.
   B. \(\text{HSO}_3^-\) is the conjugate acid of \(\text{H}_2\text{SO}_3\).
   C. \(\text{HSO}_3^-\) is the conjugate base of \(\text{H}_2\text{SO}_3\).
   D. \(\text{H}_2\text{SO}_3\) and \(\text{HSO}_3^-\) are conjugate acids of each other.

26. The conjugate acid of \(\text{PO}_4^{3-}\) is:
   A. \(\text{H}_2\text{PO}_4^-\)  
   B. \(\text{H}_3\text{PO}_4\)  
   C. \(\text{HPO}_4^{2-}\)  
   D. \(\text{H}_3\text{O}^+\)  

27. Consider the following equilibria.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>(\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^-)</td>
</tr>
<tr>
<td>II</td>
<td>(\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NH}_3)</td>
</tr>
<tr>
<td>III</td>
<td>(\text{HSO}_3^- + \text{H}_3\text{O}^+ \rightleftharpoons \text{H}_2\text{O} + \text{H}_2\text{SO}_3)</td>
</tr>
</tbody>
</table>

Water acts as a Bronsted-Lowry base in:
   A. I, II and III.  
   B. III only.  
   C. I and II only.  
   D. II and III only.

28. Which of the following is a general property of a base?
   A. It liberates hydrogen gas when reacting with magnesium.
   B. It tastes sour.
   C. It feels slippery.
   D. It turns blue litmus paper red.

29. Which of the following is a property of both acids and bases in aqueous solution?
   A. slippery feel  
   B. sour taste  
   C. reaction with \(\text{Na}_2\text{CO}_3\) to produce \(\text{CO}_2(g)\)  
   D. electrical conductivity

30. Which one of the following is the weakest acid?
    A. \(\text{HClO}_4\)  
    B. \(\text{HClO}\)  
    C. \(\text{HClO}_2\)  
    D. \(\text{HClO}_3\)

31. Which of the following compounds is a strong base in solution?
    A. \(\text{NH}_4\text{Cl}\)  
    B. \(\text{LiOH}\)  
    C. \(\text{NaHS}\)  
    D. \(\text{K}_2\text{CO}_3\)

32. Which of the following is the weakest base in solution?
    A. \(\text{CO}_3^{2-}\)  
    B. \(\text{F}^-\)  
    C. \(\text{HS}^-\)  
    D. \(\text{CN}^-\)
33. Consider the following equilibria.

\[
\begin{align*}
\text{HNO}_2 + \text{Br}^- & \rightleftharpoons \text{HBrO} + \text{NO}_2^- & K_{eq} = 2.4 \times 10^5 \\
\text{H}_2\text{SiO}_3 + \text{Br}^- & \rightleftharpoons \text{HBrO} + \text{HSiO}_3^- & K_{eq} = 9.5 \times 10^{-2} \\
\text{HIO}_4 + \text{NO}_2^- & \rightleftharpoons \text{HNO}_2 + \text{IO}_4^- & K_{eq} = 45
\end{align*}
\]

The strongest acid is:
A. \(\text{H}_2\text{SiO}_3\)  
B. \(\text{HIO}_4\)  
C. \(\text{HBrO}\)  
D. \(\text{HNO}_2\)

34. Consider the following equilibria.

\[
\begin{align*}
\text{HNO}_2 + \text{Br}^- & \rightleftharpoons \text{HBrO} + \text{NO}_2^- & K_{eq} = 2.4 \times 10^5 \\
\text{H}_2\text{SiO}_3 + \text{Br}^- & \rightleftharpoons \text{HBrO} + \text{HSiO}_3^- & K_{eq} = 9.5 \times 10^{-2} \\
\text{HIO}_4 + \text{NO}_2^- & \rightleftharpoons \text{HNO}_2 + \text{IO}_4^- & K_{eq} = 45
\end{align*}
\]

The strongest base is:
A. \(\text{HSiO}_3^-\)  
B. \(\text{NO}_2^-\)  
C. \(\text{Br}^-\)  
D. \(\text{IO}_4^-\)

35. The concentration, \(K_a\) and pH values of four acids are given in the following table.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Concentration</th>
<th>(K_a) (\times 10^{-5})</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA</td>
<td>3.0 M</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>HB</td>
<td>0.7 M</td>
<td>4.0</td>
<td>2.3</td>
</tr>
<tr>
<td>HC</td>
<td>4.0 M</td>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>HD</td>
<td>1.5 M</td>
<td>1.3</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Based on this data, the strongest acid is:
A. HD.  
B. HA.  
C. HB.  
D. HC.

36. Consider the following equilibrium system.

\[
\begin{align*}
\text{HC}_3\text{H}_5\text{O}_2 + \text{HCO}_3^- & \rightleftharpoons \text{C}_3\text{H}_5\text{O}_2^- + \text{H}_2\text{CO}_3 & K_{eq} = 32
\end{align*}
\]

The strongest acid in the above equilibrium is:
A. \(\text{HC}_3\text{H}_5\text{O}_2\)  
B. \(\text{HCO}_3^-\)  
C. \(\text{H}_2\text{CO}_3\)  
D. \(\text{C}_3\text{H}_5\text{O}_2^-\)
37. At 10°C, $K_w = 0.656 \times 10^{-14}$. Water at 10°C may be described as:
   A. neutral with $[H_3O^+] = 1.0 \times 10^{-7}$ M.  
   B. acidic with $[H_3O^+] = 8.1 \times 10^{-8}$ M.  
   C. basic with $[H_3O^+] = 8.1 \times 10^{-8}$ M.  
   D. neutral with $[H_3O^+] = 8.1 \times 10^{-8}$ M.  
   E. neutral with $[H_3O^+] = 3.28 \times 10^{-15}$

38. Consider the following equilibrium:
   
   $$2 \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^- \quad \Delta H = +57 \text{ kJ}$$

   If the temperature of the water is increased, the pH of a neutral solution:
   A. decreases as the $[H_3O^+]$ decreases.  
   B. remains constant.  
   C. decreases as the $[H_3O^+]$ increases.  
   D. increases as the $[H_3O^+]$ increases.

39. A student heats a sample of water and measures the $[H_3O^+]$ at various temperatures giving the following data.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[H_3O^+]$</td>
<td>$4.4 \times 10^{-8}$ M</td>
<td>$8.2 \times 10^{-8}$ M</td>
<td>$1.3 \times 10^{-7}$ M</td>
<td>$3.2 \times 10^{-7}$ M</td>
</tr>
</tbody>
</table>

These data suggest that as water is heated:
   A. it becomes more acidic.  
   B. the pH increases.  
   C. $[H_3O^+]$ increases while the $[OH^-]$ decreases.  
   D. the value of Kw increases  
   E. ALL of these answers are true

40. Which of the following 0.10 M solutions would have the greatest $[OH^-]$?
   A. CH$_3$COO$^-$  
   B. NO$_2^-$  
   C. SO$_3^{2-}$  
   D. PO$_4^{3-}$

41. Consider the following data:

<table>
<thead>
<tr>
<th>Solution</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
<td>8.00</td>
</tr>
<tr>
<td>two</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Which statement is correct?
   A. $[H_3O^+]$ in solution two is 6 times greater than in solution one.  
   B. $[H_3O^+]$ in solution one is 4 times greater than in solution two.  
   C. $[H_3O^+]$ in solution one is 100 000 000 times greater than in solution two.  
   D. $[H_3O^+]$ in solution two is 10 000 000 greater than in solution one.  
   E. $[H_3O^+]$ in solution one is 6 times greater than in solution two.
42. As the \([H_2O^+]\) in a solution increases due to the addition of an acid:
   A. the pH decreases, and the pOH decreases.  
   B. the pH increases, and the pOH increases.
   C. the pH increases, and the pOH decreases.  
   D. the pH decreases, and the pOH increases.

43. Consider the following 1.0 M solutions.

   NaOH, HCl, and NaCl

   Which of the following lists these solutions in increasing order of pH?
   A. HCl, NaCl, NaOH  
   B. NaOH, NaCl, HCl  
   C. HCl, NaOH, NaCl  
   D. NaOH, HCl, NaCl

44. The pH of an aqueous solution is always equal to:
   A. pOH - 14.  
   B. pOH.  
   C. 14.00 - pOH.  
   D. 14 + pOH.  
   E. pK_w - pOH

45. Consider the following acid-base reaction:

   \(H_2PO_4^{-}(aq) + HCO_3^{-}(aq) \rightleftharpoons HPO_4^{2-}(aq) + H_2CO_3(aq)\)

   A. \(HCO_3^{-}\) is the stronger acid and products are favoured.
   B. \(H_2CO_3\) is the stronger acid and reactants are favoured.
   C. \(H_2PO_4^{-}\) is the stronger acid and products are favoured.
   D. \(HPO_4^{2-}\) is the stronger acid and reactants are favoured.

46. Consider the following equilibrium system:

   \(OCl^{-}(aq) + HC_7H_5O_2(aq) \rightleftharpoons HOCl(aq) + C_7H_5O_2(aq)\)  
   \(K_{eq} = 2.1 \times 10^3\)

   At equilibrium:
   A. reactants are favoured and \(HC_7H_5O_2\) is the stronger acid.
   B. products are favoured and \(HOCl\) is the stronger acid.
   C. reactants are favoured and \(HOCl\) is the stronger acid.
   D. products are favoured and \(HC_7H_5O_2\) is the stronger acid.

47. Consider the following.

   \(SO_4^{2-} + HNO_2 \rightleftharpoons HSO_4^- + NO_2^-\)

   Equilibrium would favour:
   A. the reactants since \(HSO_4^-\) is a stronger acid than \(HNO_2\).
   B. the products since \(HSO_4^-\) is a weaker acid than \(HNO_2\).
   C. the reactants since \(HSO_4^-\) is a weaker acid than \(HNO_2\).
   D. the products since \(HSO_4^-\) is a stronger acid than \(HNO_2\).
48. The strongest base that can exist in water is:
   A. OH⁻ B. NH₂⁻ C. NH₃ D. O²⁻

49. Consider the following conductivity apparatus:

Which of the following solutions would cause the light bulb to glow the brightest?
A. H₂CO₃ B. HCN C. HNO₂ D. H₂SO₃

50. The expression for the ionization constant of water is:
A. \( K_w = [H_3O^+] + [OH^-] \) B. \( K_w = \frac{[H_3O^+]}{[OH^-]} \)
C. \( K_w = [H_3O^+] [OH^-] \) D. \( K_w = \frac{[H_3O^+] [OH^-]}{[H_2O]} \)

51. Which of the following describes the relationship between pKₚ, pOH, and pH?

52. In a solution of NaOH:
A. the \([H_3O^+] > 10^{-7} \text{ M and } [OH^-] < 10^{-7} \text{ M.} \) B. \([H_3O^+] < 10^{-7} \text{ M and } [OH^-] < 10^{-7} \text{ M.} \)
C. \([H_3O^+] < 10^{-7} \text{ M and } [OH^-] > 10^{-7} \text{ M.} \) D. \([H_3O^+] > 10^{-7} \text{ M and } [OH^-] > 10^{-7} \text{ M.} \)

53. What is the [OH⁻] in 0.50 M HCl?
A. 2.0 \times 10^{-14} \text{ M} B. 13.70 \text{ M} C. 0.50 \text{ M} D. 0.30 \text{ M}

54. Which of the following acids will have the greatest [OH⁻]?
A. 1.0 M H₂SO₄ B. 1.0 M HI C. 1.0 M HF D. 1.0 M HCN
55. The conjugate base of $\text{HAsO}_4^{2-}$ is

A. $\text{H}_3\text{O}^+$
B. $\text{AsO}_4^{3-}$
C. $\text{H}_3\text{AsO}_4$
D. $\text{H}_2\text{AsO}_4$

56. Consider the following acid-base equilibrium:

$$\text{HC}_6\text{H}_5\text{O}_7^{2-} + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{H}_2\text{C}_6\text{H}_5\text{O}_7^- + \text{HPO}_4^{2-}$$

In the equilibrium above,

A. products are favoured because $\text{H}_2\text{PO}_4^-$ is the weaker acid
B. reactants are favoured because $\text{HPO}_4^{2-}$ is the weaker acid
C. products are favoured because $\text{HC}_6\text{H}_5\text{O}_7^{2-}$ is the weaker acid
D. reactants are favoured because $\text{HC}_6\text{H}_5\text{O}_7^{2-}$ is the weaker base

57. Calculate the $[\text{H}_3\text{O}^+]$ in a 0.005 M solution of Sr(OH)$_2$.

A. $5.0 \times 10^{-13}$ M
B. $1.0 \times 10^{-12}$ M
C. $1.0 \times 10^{-2}$ M
D. $2.0 \times 10^{-2}$ M

58. The conjugate acid of $\text{H}_2\text{PO}_4^-$ is

A. $\text{PO}_4^{3-}$
B. $\text{HPO}_4^-$
C. $\text{HPO}_4^{2-}$
D. $\text{H}_3\text{PO}_4$

59. The electrical conductivities of 0.010M solutions of NaCl, HCN and HNO$_2$ are measured. The order by conductivity from highest to lowest is

A. NaCl > HNO$_2$ > HCN
B. HCN > HNO$_2$ > NaCl
C. NaCl > HCN > HNO$_2$
D. HNO$_2$ > HCN > NaCl
60. Which of the following acids has the weakest conjugate base?

A. \( \text{H}_2\text{C}_2\text{O}_4 \)
B. HF
C. \( \text{H}_3\text{PO}_4 \)
D. HCN

61. Which of the following represents the reaction of \( \text{H}_2\text{PO}_4^- \) acting as a base?

A. \( \text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{PO}_4 + \text{OH}^- \)
B. \( \text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{H}_3\text{PO}_4 \)
C. \( \text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HPO}_4^{2-} \)
D. \( \text{H}_2\text{PO}_4^- + 2\text{H}_2\text{O} \rightleftharpoons \text{H}_4\text{PO}_4^+ + 2\text{OH}^- \)

62. An acidic solution can be defined as one in which

A. \([\text{H}_3\text{O}^+]\) is not present
B. \([\text{H}_3\text{O}^+]\) is equal to \([\text{OH}^-]\)
C. \([\text{H}_3\text{O}^+]\) is less than \([\text{OH}^-]\)
D. \([\text{H}_3\text{O}^+]\) is greater than \([\text{OH}^-]\)

63. What is \([\text{OH}^-]\) in 0.025 M \( \text{HNO}_3 \)?

A. \( 4.0 \times 10^{-13} \) M
B. 0.025 M
C. 1.60 M
D. 12.40 M

64. Which of the following relationships is used to calculate \( \text{Kw} \) at 30°C?

A. \( \text{Kw} = \text{pH} + \text{pOH} \)
B. \( \text{pKw} = -\log[\text{H}_3\text{O}^+] \)
C. \( \text{Kw} = [\text{H}_3\text{O}^+] [\text{OH}^-] \)
D. \( \text{Kw} = [\text{H}_3\text{O}^+] + [\text{OH}^-] \)

65. Which of the following \( \text{Kb} \) values represents the base with the strongest conjugate acid?

A. \( \text{Kb} = 4.2 \times 10^{-11} \)
B. \( \text{Kb} = 9.5 \times 10^{-5} \)
C. \( \text{Kb} = 2.0 \times 10^{-3} \)
D. \( \text{Kb} = 7.8 \times 10^{-2} \)
66. Consider the ionization of water:

\[ 2 \text{H}_2\text{O} (l) \Rightarrow \text{H}_3\text{O}^+ (aq) + \text{OH}^- (aq) \]

What happens to the pH when 0.1M HNO\textsubscript{3} is added to water?

A. pH increases and [OH\textsuperscript{-}] increases.
B. pH increases and [OH\textsuperscript{-}] decreases.
C. pH decreases and [OH\textsuperscript{-}] increases.
D. pH decreases and [OH\textsuperscript{-}] decreases.
E. pH remains the same

67. Since the ionization of water is endothermic, which of the following is true at 12°C?

A. \( Kw = \frac{K_a}{K_b} \)
B. \( Kw = \frac{K_b}{K_a} \)
C. \( Kw > 1.0 \times 10^{-14} \)
D. \( Kw < 1.0 \times 10^{-14} \)

68. When 10.0 mL of 0.10M HCl is added to 10.0 mL of water, the concentration of OH\textsuperscript{-} in the final solution is

A. 0.010 M
B. 0.050 M
C. 1.0 \times 10^{-12} M
D. 2.0 \times 10^{-13} M

69. Which of the following chemical species are amphiprotic in aqueous solution?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>I.</td>
<td>C\textsubscript{2}O\textsubscript{4}\textsuperscript{2-}</td>
</tr>
<tr>
<td>II.</td>
<td>HS\textsuperscript{-}</td>
</tr>
<tr>
<td>III.</td>
<td>H\textsubscript{2}PO\textsubscript{4}\textsuperscript{-}</td>
</tr>
</tbody>
</table>

A. I only
B. II only
C. III only
D. II and III only
70. Consider the following equilibrium:

\[ 2\text{H}_2\text{O} (l) + \text{energy} \rightleftharpoons \text{H}_3\text{O}^+ (aq) + \text{OH}^- (aq) \]

The \([\text{H}_3\text{O}^+]\) and the \([\text{OH}^-]\) will both decrease when

A. a strong acid is added  
B. a strong base is added  
C. the temperature is increased  
D. the temperature is decreased

71. A Bronsted-Lowry base is defined as a compound that

A. accepts \(\text{OH}^-\) in solution.  
B. releases \(\text{OH}^-\) in solution.  
C. accepts protons in solution.  
D. donates protons in solution.

72. Consider the equilibrium:

\[ \text{HF} (aq) + \text{HPO}_4^{2-} (aq) \rightleftharpoons \text{F}^- (aq) + \text{H}_2\text{PO}_4^- (aq) \]

For the above equilibrium, identify the stronger acid and determine whether reactants or products are favoured.

<table>
<thead>
<tr>
<th>Weak Acids</th>
<th>Side Favoured</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. HF</td>
<td>Products</td>
</tr>
<tr>
<td>B. HF</td>
<td>Reactants</td>
</tr>
<tr>
<td>C. H$_2$PO$_4^-$</td>
<td>Products</td>
</tr>
<tr>
<td>D. H$_2$PO$_4^-$</td>
<td>Reactants</td>
</tr>
</tbody>
</table>

73. Which of the following will have the largest \(K_b\) value?

A. \(\text{IO}_3^-\)  
B. \(\text{NH}_3\)  
C. \(\text{CN}^-\)  
D. \(\text{HPO}_4^{2-}\)
74. Four acids are analyzed and their Ka values are determined. Which of the following values represents the weakest acid?

A. \( \text{Ka} = 2.2 \times 10^{-2} \)
B. \( \text{Ka} = 6.2 \times 10^{-9} \)
C. \( \text{Ka} = 1.7 \times 10^{-12} \)
D. \( \text{Ka} = 1.2 \times 10^{-15} \)

75. Which of the following is generally true of bases, but **not** for acids?

A. \( \text{pH} < 7 \)
B. feel slippery
C. conduct current when in solution
D. cause indicators to change colour

76. Identify the common acid used for etching copper.

A. nitric acid
B. sulphuric acid
C. perchloric acid
D. hydrochloric acid

77. Consider the following equilibrium:

\[
\text{HCO}_3^- + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{HPO}_4^{2-} + \text{H}_2\text{CO}_3
\]

What are the Bronsted-Lowry bases in this equilibrium?

A. \( \text{HCO}_3^- \) and \( \text{H}_2\text{CO}_3 \)
B. \( \text{HCO}_3^- \) and \( \text{HPO}_4^{2-} \)
C. \( \text{H}_2\text{PO}_4^- \) and \( \text{H}_2\text{CO}_3 \)
D. \( \text{H}_2\text{PO}_4^- \) and \( \text{HPO}_4^{2-} \)

78. What happens to the ion concentrations in water when a small amount of KOH (aq) is added?

A. \([\text{H}_3\text{O}^+] = [\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}\)
B. \([\text{H}_3\text{O}^+]\) and \([\text{OH}^-]\) both increase
C. \([\text{H}_3\text{O}^+]\) decreases and \([\text{OH}^-]\) increases
D. \([\text{H}_3\text{O}^+]\) increases and \([\text{OH}^-]\) is unchanged
Chemistry 12 – Provincial Practice Questions
Written Response Questions

1. Consider the following amphiprotic anions reacting with each other:

\[ \text{H}_2\text{C}_6\text{H}_5\text{O}_7^- + \text{H}_2\text{PO}_4^- \rightleftharpoons ? \]

a) Complete the Bronsted-Lowry acid-base equilibrium for the predominant reaction. Write your answer here:

___________________________________________________________________

b) Does the equilibrium above favour reactants or products? ____________

c) Explain your answer to (b).

2. Calculate the pH of a 2.5 M \( \text{C}_6\text{H}_5\text{OH} \) solution.
3. Calculate the pH of a 0.60 M NaNO\textsubscript{2} solution.

4. Calculate the pH of 0.45 M Ra(OH)\textsubscript{2}.

5. Write the balanced formula equation to represent the complete neutralization reaction between aluminum hydroxide and sulphuric acid.

   ___________________________________________________________________

6. a) Write the net ionic equation for the acid-base reaction that occurs between KF\textsubscript{(aq)} and NH\textsubscript{4}NO\textsubscript{3(aq)}. (2 marks)

   ___________________________________________________________________

b) Are reactants or products favoured at equilibrium? (1 mark)

   ____________________________ are favoured.
7. A sample of pure KOH (s) is dissolved in water to make 8.0 L of solution and a pH = 9.82 results. Calculate the mass of pure KOH that was dissolved. (3 marks)

8. At 20°C, the pOH of a sample of water is 7.085. Calculate the value of Kw for water at 20°C using this data.

9. a) Which has a higher conductivity, 2.0 M H₂S or 0.01 M HBr? 

   b) Justify your answer using calculations.
10. At a particular temperature a 1.0 M HCN solution has a pH = 4.05. Calculate the value of $K_a$ at this temperature. (4 marks)

11. A 0.65 M solution of CN$^-$ has a pH of 12.13 at a certain temperature. Calculate the $K_b$ of CN$^-$ at this temperature. (Assume $pK_a = 14.00$)

12. Explain why $H_3O^+$ is the strongest acid possible in aqueous solution.

13. What is the pH of a 0.70 M oxide solution?
14. Write the equation for an amphiprotic anion acting as an acid with water.

____________________________________________________________________

15. How much water needs to be added to 500.0 mL of a solution of pH = 2.000 to bring the pH to 2.301.

16. A 0.60 M solution of a weak acid has a pH = 1.78. Use calculations and the table of acids to identify which acid it is.

a) Write an equation to represent the predominant reaction when HC₆H₅O₇⁻ is mixed with HCO₃⁻. (1 mark)

____________________________________________________________________

b) Justify your statement by comparing Ka values. (1 mark)

c) Identify a conjugate acid-base pair. (1 mark)

______________ and ______________

d) Predict whether equilibrium will favour the production of reactants or products. Explain. (2 marks)

Prediction: _____________________________________________________________

Explanation: ___________________________________________________________________