Provincial Exam MC Questions: Unit 4 Acid-Base

January 1999

21. Consider the following acid-base equilibrium:

\[
\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^- 
\]

In the reaction above, the Brønsted-Lowry acids are

A. \(\text{H}_2\text{O}\) and \(\text{OH}^-\)
B. \(\text{HCO}_3^-\) and \(\text{OH}^-\)
C. \(\text{H}_2\text{O}\) and \(\text{H}_2\text{CO}_3\)
D. \(\text{HCO}_3^-\) and \(\text{H}_2\text{CO}_3\)

22. Consider the following solubility equilibrium:

\[
\text{Mg(OH)}_2_{(s)} \rightleftharpoons \text{Mg}^{2+}_{(aq)} + 2\text{OH}^-_{(aq)}
\]

A compound that could be added to cause this equilibrium to shift to the right is

A. \(\text{Na}_2\text{O}\)
B. \(\text{NH}_4\text{Cl}\)
C. \(\text{Sr(OH)}_2\)
D. \(\text{Mg(OH)}_2\)

23. The solution with the lowest electrical conductivity is

A. 0.10M \(\text{H}_2\text{S}\)
B. 0.10M \(\text{HNO}_2\)
C. 0.10M \(\text{H}_2\text{SO}_3\)
D. 0.10M \(\text{NH}_4\text{Cl}\)

24. The solution with the lowest pH is

A. 1.0M \(\text{HF}\)
B. 1.0M \(\text{HCN}\)
C. 1.0M \(\text{HCOOH}\)
D. 1.0M \(\text{CH}_3\text{COOH}\)

25. As the \([\text{H}_3\text{O}^+]\) in a solution decreases, the \([\text{OH}^-]\)

A. increases and the pH increases.
B. increases and the pH decreases.
C. decreases and the pH increases.
D. decreases and the pH decreases.

26. The value of pK\(_w\) at 25°C is

A. \(1.0 \times 10^{-14}\)
B. \(1.0 \times 10^{-7}\)
C. 7.00
D. 14.00
27. Consider the following equilibrium:

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

In pure water at a temperature of 50°C,

A. pH < 7  
B. pH + pOH = 14  
C. \( K_w = 1.0 \times 10^{-14} \)  
D. \([\text{OH}^-]\) < 1.0 \times 10^{-7}

28. What is the pOH of 2.5 M NaOH?

A. −0.40  
B. 0.0032  
C. 0.40  
D. 13.60

29. A 0.010M acid solution has a pH of 2.00. The acid could be

A. HNO_3  
B. H_2SO_3  
C. HCOOH  
D. CH_3COOH

30. Which of the following salts dissolves to produce a basic aqueous solution?

A. LiF  
B. KClO_4  
C. NaHSO_3  
D. NH_4NO_3

31. Which titration curve represents the titration of HCl with NaOH?

A.  
B.  
C.  
D.  

32. A buffer solution can be formed by dissolving equal moles of
A. HF and NaF  
B. HCl and NaOH  
C. KBr and Na₃PO₄  
D. CH₃COOH and NaCl

33. Which of the following gases is a contributor to the formation of acid rain? 
A. H₂  
B. O₃  
C. SO₂  
D. NH₃

34. During a titration, an indicator is found to change colour when the [H₃O⁺] = 1×10⁻⁶ M. Identify the indicator. 
A. methyl violet  
B. alizarin yellow  
C. phenolphthalein  
D. chlorophenol red

35. Consider the following: 

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>I</td>
<td>PO₄³⁻</td>
</tr>
<tr>
<td>II</td>
<td>HPO₄²⁻</td>
</tr>
<tr>
<td>III</td>
<td>H₂PO₄⁻</td>
</tr>
<tr>
<td>IV</td>
<td>H₃PO₄</td>
</tr>
</tbody>
</table>

The term amphiprotic can be used to describe 
A. I only.  
B. II and III only.  
C. I, II and III only.  
D. II, III and IV only.

36. Calculate the [H₃O⁺] in a solution prepared by mixing 25.0mL of 1.0M HCl with 50.0mL of 0.50M KOH. 
A. 1.0 M  
B. 0.50 M  
C. 0.25 M  
D. 1.0 × 10⁻² M
21. Which of the following is a property of sodium hydroxide?

A. feels slippery  
B. releases $H_3O^+$ in aqueous solution  
C. changes litmus paper from blue to red  
D. reacts with magnesium to produce hydrogen gas

22. The conjugate acid of $H_{AsO_4^{2-}}$ is

A. $H_3O^+$  
B. $AsO_4^{3-}$  
C. $H_3AsO_4$  
D. $H_2AsO_4^-$

23. Which of the following 0.10M solutions has the highest electrical conductivity?

A. HF  
B. HCN  
C. $H_2CO_3$  
D. $H_3BO_3$

24. Consider the following acid-base equilibrium:

$$H_2C_6H_5O_7^- + HPO_4^{2-} \rightleftharpoons HC_6H_5O_7^{2-} + H_2PO_4^-$$

In the equilibrium above,

A. products are favoured because $H_2PO_4^-$ is the weaker acid.  
B. reactants are favoured because $HPO_4^{2-}$ is the weaker acid.  
C. products are favoured because $HC_6H_5O_7^{2-}$ is the weaker acid.  
D. reactants are favoured because $H_2C_6H_5O_7^-$ is the weaker acid.

25. Which of the following describes the relationship between $[H_3O^+]$ and $[OH^-]$?

A. $[H_3O^+][OH^-] = 14.00$  
B. $[H_3O^+] + [OH^-] = 14.00$  
C. $[H_3O^+][OH^-] = 1.0 \times 10^{-14}$  
D. $[H_3O^+] + [OH^-] = 1.0 \times 10^{-14}$

26. Consider the following equilibrium:

$$2H_2O + \text{energy} \rightleftharpoons H_3O^+ + OH^-$$

When water has a pH of 7.5, the temperature is

A. less than 25°C and the solution is basic.  
B. less than 25°C and the solution is neutral.  
C. greater than 25°C and the solution is basic.  
D. greater than 25°C and the solution is neutral.
27. Calculate the \([H_3O^+]\) in a 0.010M solution of \(\text{Sr(OH)}_2\).

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

28. The value of \(K_b\) for \(\text{HCO}_3^-\) is

A. \(5.6 \times 10^{-11}\)  
B. \(2.3 \times 10^{-8}\)  
C. \(4.3 \times 10^{-7}\)  
D. \(1.8 \times 10^{-4}\)

29. The net ionic equation for the hydrolysis of \(\text{NH}_4\text{ClO}_4\) is

A. \(\text{NH}_4\text{ClO}_4(s) \rightleftharpoons \text{NH}_4^+ + \text{ClO}_4^-\)  
B. \(\text{NH}_4^+(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_3(aq) + \text{H}_3\text{O}^+(aq)\)  
C. \(\text{ClO}_4^-(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{HClO}_4(aq) + \text{OH}^-(aq)\)  
D. \(\text{NH}_4^+(aq) + \text{ClO}_4^-(aq) \rightleftharpoons \text{NH}_3(aq) + \text{HClO}_4(aq)\)

30. A sample of an unknown solution is tested with the indicator chlorophenol red. The solution turns yellow on the addition of this indicator. The solution could be

A. 1.0M KF  
B. 1.0M NaCl  
C. 1.0M Li$_2$SO$_4$  
D. 1.0M NH$_4$NO$_3$

31. Which of the following indicators has a transition point closest to the equivalence point for the titration of a weak acid by a strong base?

A. orange IV  
B. thymol blue  
C. methyl orange  
D. bromcresol green

32. A buffer solution is formed by adding which of the following to water?

A. HCl and KOH  
B. HCN and RbCN  
C. NaBr and NaOH  
D. HNO$_3$ and LiNO$_3$

33. A solution of known concentration is the definition of a
A. buffer solution.
B. neutral solution.
C. standard solution.
D. saturated solution.

34. Which of the following is responsible for the acidic pH of normal rainwater?
A. CO₂
B. NO₂
C. SO₂
D. NH₃

35. A solution contains a mixture of methyl orange, phenol red and thymol blue. When this solution is yellow, the pH is
A. 3.0
B. 6.0
C. 9.0
D. 12.0

36. Which of the following represents the reaction between MgO and H₂O?
A. MgO + H₂O → Mg(OH)₂
B. MgO + H₂O → MgH₂ + O₂
C. MgO + H₂O → Mg + H₂O₂
D. 2MgO + H₂O → 2MgOH + ½ O₂

June 1999

19. A 1.0 × 10⁻⁴ M solution has a pH of 10.00. The solute is a
A. weak acid.
B. weak base.
C. strong acid.
D. strong base.

20. Consider the following Brønsted-Lowry equilibrium system:

\[ \text{HSO}_3^- + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{PO}_4 \]

What are the two Brønsted-Lowry bases in the equilibrium above?
A. HSO₃⁻ and SO₃²⁻
B. H₂PO₄⁻ and SO₃²⁻
C. HSO₃⁻ and H₃PO₄
D. H₂PO₄⁻ and H₃PO₄
21. The equation representing the predominant reaction of sodium ethanoate, NaCH₃COO, with water is

A. CH₃COO⁻ + H₂O ⇌ CH₃COOH + OH⁻
B. CH₃COO⁻ + H₂O ⇌ H₃O⁺ + CH₂COO⁻
C. CH₃COOH + H₂O ⇌ H₃O⁺ + CH₃COO⁻
D. CH₃COOH + H₂O ⇌ CH₃COOH₂⁺ + OH⁻

22. Which of the following solutions will have the lowest electrical conductivity?

A. 0.1M HF
B. 0.1M NaF
C. 0.1M H₂SO₃
D. 0.1M NaHSO₃

23. Which of the following is the strongest Brönsted-Lowry base?

A. NH₃
B. CO₃²⁻
C. HSO₃⁻
D. H₂BO₃⁻

24. Consider the following:

<table>
<thead>
<tr>
<th>ION</th>
</tr>
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<tbody>
<tr>
<td>I. HCO₃⁻</td>
</tr>
<tr>
<td>II. H₂PO₄⁻</td>
</tr>
<tr>
<td>III. CH₃COO⁻</td>
</tr>
</tbody>
</table>

The amphiprotic ions are

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

25. The ionization of water at room temperature is represented by

A. H₂O ⇌ 2H⁺ + O²⁻
B. 2H₂O ⇌ 2H₂ + O₂
C. 2H₂O ⇌ H₂ + 2OH⁻
D. 2H₂O ⇌ H₃O⁺ + OH⁻

26. Addition of HCl to water causes
A. both [H₃O⁺] and [OH⁻] to increase.
B. both [H₃O⁺] and [OH⁻] to decrease.
C. [H₃O⁺] to increase and [OH⁻] to decrease.
D. [H₃O⁺] to decrease and [OH⁻] to increase.

27. Which of the following graphs describes the relationship between [H₃O⁺] and [OH⁻] in aqueous solutions at a constant temperature?

A. 
\[
\text{[OH}^\text{−}] \quad \text{[H}_3\text{O}^\text{+}]
\]

B. 
\[
\text{[OH}^\text{−}] \quad \text{[H}_3\text{O}^\text{+}]
\]

C. 
\[
\text{[OH}^\text{−}] \quad \text{[H}_3\text{O}^\text{+}]
\]

D. 
\[
\text{[OH}^\text{−}] \quad \text{[H}_3\text{O}^\text{+}]
\]

28. Consider the following:

|    |   
|----|--- |
| I. | H₂SO₄ |
| II. | HSO₄⁻ |
| III. | SO₄²⁻ |

Which of the above is/are present in a reagent bottle labeled 1.0M H₂SO₄?

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

29. The pH of a 0.10M KOH solution is

A. 0.10
B. 1.00
C. 13.00
D. 14.10
30. The equilibrium expression for the predominant reaction between the hydrogen oxalate ion, $\text{HC}_2\text{O}_4^-$, and water is

A. $K_a = \frac{[\text{C}_2\text{O}_4^{2-}] [\text{H}_3\text{O}^+]}{[\text{HC}_2\text{O}_4^-]}$

B. $K_b = \frac{[\text{HC}_2\text{O}_4^-]}{[\text{C}_2\text{O}_4^{2-}][\text{OH}^-]}$

C. $K_a = \frac{[\text{HC}_2\text{O}_4^-][\text{H}_3\text{O}^+]}{[\text{C}_2\text{O}_4^{2-}]}$

D. $K_b = \frac{[\text{H}_2\text{C}_2\text{O}_4][\text{OH}^-]}{[\text{HC}_2\text{O}_4^-]}$

31. Which of the following salts will dissolve in water to produce a neutral solution?

A. LiF
B. CrCl$_3$
C. KNO$_3$
D. NH$_4$Cl

32. An indicator changes colour in the pH range 9.0 to 11.0. What is the value of $K_a$ for the indicator?

A. $1 \times 10^{-13}$
B. $1 \times 10^{-10}$
C. $1 \times 10^{-7}$
D. $1 \times 10^1$

33. Which of the following always applies at the transition point for the indicator HInd?

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

34. Calculate the $[\text{H}_3\text{O}^+]$ of a solution prepared by adding 10.0mL of 2.0M HCl to 10.0mL of 1.0M NaOH.

A. 0.020 M
B. 0.50 M
C. 1.0 M
D. 2.0 M

35. Consider the following:
The purpose of a buffer system consisting of CH₃COOH and CH₃COONa is to maintain a relatively constant concentration of

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

36. Which of the following, when dissolved in water, will produce an acidic solution?

A. SrO
B. NO₂
C. CaO
D. Na₂O

August 1999

22. An Arrhenius acid is defined as a chemical species that

A. is a proton donor.
B. is a proton acceptor.
C. produces hydrogen ions in solution.
D. produces hydroxide ions in solution.

23. Consider the acid-base equilibrium system:

\[ \text{H}_2\text{S}_\text{O}_4^- + \text{H}_2\text{BO}_3^- \rightleftharpoons \text{H}_3\text{BO}_3 + \text{C}_2\text{O}_4^{2-} \]

Identify the Brønsted-Lowry bases in this equilibrium.

A. H₂BO₃⁻ and H₃BO₃
B. HC₂O₄⁻ and H₂BO₃
C. HC₂O₄⁻ and C₂O₄²⁻
D. H₂BO₃⁻ and C₂O₄²⁻

24. An equation representing the reaction of a weak acid with water is

A. HCl + H₂O \rightarrow H₂O⁺ + Cl⁻
B. NH₃ + H₂O \rightleftharpoons NH₄⁺ + OH⁻
C. HCO₃⁻ + H₂O \rightleftharpoons H₂CO₃ + OH⁻
D. HCOOH + H₂O \rightleftharpoons H₂O⁺ + HCOO⁻
25. The equilibrium expression for the ion product constant of water is

A. \[ \frac{[H_3O^+][OH^-]}{[H_2O]} \]

B. \( K_w = [H_3O^+]^2[O_2] \)

C. \( K_w = [H_3O^+][OH^-] \)

D. \( K_w = [H_3O^+]^2[O^2_] \)

26. Consider the following equilibrium:

\[
2H_2O + \text{energy} \rightleftharpoons H_3O^+ + OH^- 
\]

Which of the following describes the result of decreasing the temperature?

<table>
<thead>
<tr>
<th>( [H_3O^+] )</th>
<th>( [OH^-] )</th>
<th>( K_w )</th>
</tr>
</thead>
<tbody>
<tr>
<td>increases</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>decreases</td>
<td>increases</td>
<td>decreases</td>
</tr>
<tr>
<td>increases</td>
<td>decreases</td>
<td>no change</td>
</tr>
<tr>
<td>decreases</td>
<td>decreases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

27. In an acidic solution at 25°C,

A. \( [H_3O^+] < [OH^-] \) and pH > 7

B. \( [H_3O^+] < [OH^-] \) and pH < 7

C. \( [H_3O^+] > [OH^-] \) and pH > 7

D. \( [H_3O^+] > [OH^-] \) and pH < 7

28. The pH of a solution changes from 3.00 to 6.00. By what factor does the \( [H_3O^+] \) change?

A. 2

B. 3

C. 100

D. 1000

29. The \( K_a \) expression for the hydrogen sulphite ion, \( HSO_3^- \), is
A. \[ \begin{align*}
&\text{SO}_3^{2-} + \text{H}_3\text{O}^+ \\
&\text{K}_a = \frac{[\text{HSO}_3^-]}{[\text{SO}_3^{2-}][\text{H}_3\text{O}^+]} \\
&\text{B. } [\text{H}_2\text{SO}_3][\text{H}_3\text{O}^+] \\
&\text{K}_a = \frac{[\text{HSO}_3^-]}{[\text{H}_2\text{SO}_3][\text{H}_3\text{O}^+]} \\
\end{align*} \]

30. The \([\text{OH}^-]\) in a solution of pH 3.00 is

A. \(1.0 \times 10^{-11} \text{ M}\)  
B. \(1.0 \times 10^{-9} \text{ M}\)  
C. \(1.0 \times 10^{-6} \text{ M}\)  
D. \(1.0 \times 10^{-3} \text{ M}\)

31. Consider the following equilibrium for an indicator:

\[ \text{HInd} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Ind}^- \]

Which two species must be of two different colours in order to be used as an indicator?

A. HInd and H\(_2\)O  
B. HInd and Ind\(^-\)  
C. H\(_3\)O\(^+\) and Ind\(^-\)  
D. HInd and H\(_3\)O\(^+\)

32. Which of the following indicators is yellow at a pH of 10.0?

A. methyl red  
B. phenol red  
C. thymol blue  
D. methyl violet

33. A sample containing \(1.20 \times 10^{-2} \text{ mol HCl}\) is completely neutralized by 100.0mL of Sr(OH)\(_2\). What is the [Sr(OH)\(_2\)]?

A. \(6.00 \times 10^{-3} \text{ M}\)  
B. \(6.00 \times 10^{-2} \text{ M}\)  
C. \(1.20 \times 10^{-1} \text{ M}\)  
D. \(2.4 \times 10^{-1} \text{ M}\)

34. Which of the following titrations will have the highest pH at the equivalence point?
A. HBr with NH₃
B. HNO₂ with KOH
C. HCl with Na₂CO₃
D. HNO₃ with NaOH

35. Consider the following graph for the titration of 0.1M NH₃ with 0.1M HCl:

A buffer solution is present at point

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

36. Which of the following solutions would require the greatest volume of 1.0M NaOH for complete neutralization?

A. 10.0mL of 1.0M HCl
B. 10.0mL of 2.0M H₂SO₄
C. 10.0mL of 3.0M H₃PO₄
D. 10.0mL of 4.0M H₂C₂O₄

January 2000

22. Which of the following is a general property of bases?

A. taste sour
B. turn litmus red
C. conduct electric current in solution
D. concentration of H₃O⁺ is greater than concentration of OH⁻

23. Water will act as an acid with which of the following?
<table>
<thead>
<tr>
<th>I.</th>
<th>H₂CO₃</th>
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</thead>
<tbody>
<tr>
<td>II.</td>
<td>HCO₃⁻</td>
</tr>
<tr>
<td>III.</td>
<td>CO₃²⁻</td>
</tr>
</tbody>
</table>

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

24. Which of the following 1.0M solutions will have the greatest electrical conductivity?

A. HI  
B. H₂S  
C. HCN  
D. H₃PO₄

25. An acid is added to water and a new equilibrium is established. The new equilibrium can be described by

A. pH < pOH and K_w = 1 X 10⁻¹⁴  
B. pH < pOH and K_w < 1 X 10⁻¹⁴  
C. pH > pOH and K_w = 1 X 10⁻¹⁴  
D. pH > pOH and K_w > 1 X 10⁻¹⁴

26. Consider the following equilibrium:

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

The [H₃O⁺] will decrease and the K_w will remain constant when

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

27. Which of the following graphs describes the relationship between [H₃O⁺] and pH?

A.  
B.  
C.  
D.
28. When the $[\text{H}_3\text{O}^+]$ in a solution is increased to twice the original concentration, the change in pH could be from

A. 1.7 to 1.4  
B. 2.0 to 4.0  
C. 5.0 to 2.5  
D. 8.5 to 6.5

29. The relationship $\frac{[\text{H}_2\text{P}_2\text{O}_7^{2-}][\text{H}_3\text{O}^+]}{[\text{H}_3\text{P}_2\text{O}_7^-]}$ is the

A. $K_a$ for $\text{H}_3\text{P}_2\text{O}_7^-$  
B. $K_b$ for $\text{H}_3\text{P}_2\text{O}_7^-$  
C. $K_a$ for $\text{H}_2\text{P}_2\text{O}_7^{2-}$  
D. $K_b$ for $\text{H}_2\text{P}_2\text{O}_7^{2-}$

30. Which of the following describes the relationship between acid strength and $K_a$ value for weak acids?

<table>
<thead>
<tr>
<th>Acid Strength</th>
<th>$K_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. increases</td>
<td>increases</td>
</tr>
<tr>
<td>B. increases</td>
<td>decreases</td>
</tr>
<tr>
<td>C. decreases</td>
<td>increases</td>
</tr>
<tr>
<td>D. decreases</td>
<td>remains constant</td>
</tr>
</tbody>
</table>

31. The value of $K_b$ for $\text{HPO}_4^{2-}$ is

A. $2.2 \times 10^{-13}$  
B. $6.2 \times 10^{-8}$  
C. $1.6 \times 10^{-7}$  
D. $4.5 \times 10^{-2}$

32. Which of the following 1.0M solutions would have a pH greater than 7.00?

A. HCN  
B. KNO$_3$  
C. NH$_4$Cl  
D. NaCH$_3$COO

33. What is the pH at the transition point for an indicator with a $K_a$ of $2.5 \times 10^{-4}$?

A. $2.5 \times 10^{-4}$  
B. 3.60  
C. 7.00  
D. 10.40
34. What volume of 0.100M NaOH is required to completely neutralize 15.00mL of 0.100M H$_3$PO$_4$?

A. 5.00mL  
B. 15.0mL  
C. 30.0mL  
D. 45.0mL

35. What is the pH of the solution formed when 0.060 moles NaOH is added to 1.00L of 0.050M HCl?

A. 2.00  
B. 7.00  
C. 12.00  
D. 12.78

36. Which of the following graphs describes the relationship between the pH of a buffer and the volume of NaOH added to the buffer?

![Graph A](image1)  
![Graph B](image2)  
![Graph C](image3)  
![Graph D](image4)

37. A gas which is produced by internal combustion engines and contributes to the formation of acid rain is

A. H$_2$  
B. O$_3$  
C. CH$_4$  
D. NO$_2$

---

April 2000

22. Consider the following reaction:
The order of Brønsted-Lowry acids and bases in this equation is

A. acid, base, base, acid.
B. acid, base, acid, base.
C. base, acid, acid, base.
D. base, acid, base, acid.

23. The conjugate base of an acid is produced by

A. adding a proton to the acid.
B. adding an electron to the acid.
C. removing a proton from the acid.
D. removing an electron from the acid.

24. Which of the following represents the predominant reaction between HCO$_3^-$ and water?

A. $2\text{HCO}_3^- \rightarrow \text{H}_2\text{O} + 2\text{CO}_2$
B. $\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 + \text{OH}^-$
C. $\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{O}^+ + \text{CO}_3^{2-}$
D. $2\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{CO}_3^{2-} + \text{OH}^- + \text{CO}_2$

25. Water acts as an acid when it reacts with which of the following?

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<td>IV</td>
<td>CH$_3$COO$^-$</td>
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A. I and IV only
B. II and III only
C. I, II and IV only
D. II, III and IV only

26. In a solution of 0.10M H$_2$SO$_4$, the ions present in order of decreasing concentration are

A. $[\text{H}_3\text{O}^+] > [\text{HSO}_4^-] > [\text{SO}_4^{2-}] > [\text{OH}]$
B. $[\text{H}_3\text{O}^+] > [\text{SO}_4^{2-}] > [\text{HSO}_4^-] > [\text{OH}]$
C. $[\text{OH}] > [\text{SO}_4^{2-}] > [\text{HSO}_4^-] > [\text{H}_3\text{O}^+]$
D. $[\text{SO}_4^{2-}] > [\text{HSO}_4^-] > [\text{OH}] > [\text{H}_3\text{O}^+]$

27. Consider the following equilibrium:

$$2\text{H}_2\text{O} \quad \text{(l)} \quad \text{energy} \quad \rightarrow \quad \text{H}_3\text{O}^+ \quad \text{(aq)} \quad + \quad \text{OH}^- \quad \text{(aq)}$$

What will cause the pH to increase and the $K_w$ to decrease?
A. adding a strong acid
B. adding a strong base
C. increasing the temperature
D. decreasing the temperature

28. Which of the following graphs describes the relationship between pH and pOH?

A.  
```
\[
\text{pH} \\
\text{pOH}
\]
```

B.  
```
\[
\text{pH} \\
\text{pOH}
\]
```

C.  
```
\[
\text{pH} \\
\text{pOH}
\]
```

D.  
```
\[
\text{pH} \\
\text{pOH}
\]
```

29. \([H_3BO_3][OH^-]\)
   The relationship \----------- is the expression for \([H_2BO_3^-]\)

A. \(K_a\) for \(H_3BO_3\)
B. \(K_b\) for \(H_3BO_3\)
C. \(K_a\) for \(H_2BO_3^-\)
D. \(K_b\) for \(H_2BO_3^-\)

30. The value of \(K_b\) for \(H_2PO_4^-\) is

A. \(1.3 \times 10^{-12}\)
B. \(6.2 \times 10^{-8}\)
C. \(1.6 \times 10^{-7}\)
D. \(7.5 \times 10^{-3}\)

31. Which of the following solutions has a pH less than 7.00?

A. NaCl
B. LiOH
C. NH_4NO_3
D. KCH_3COO

32. Which of the following will form a basic aqueous solution?

A. HSO_3^-  
B. HSO_4^-
33. What is the approximate $K_a$ value for the indicator chlorophenol red?

A. $1 \times 10^{-14}$
B. $1 \times 10^{-8}$
C. $1 \times 10^{-6}$
D. $1 \times 10^{-3}$

34. What is the pH of the solution formed when 0.040mol NaOH (s) is added to 2.00L of 0.020M HCl?

A. 0.00
B. 1.40
C. 1.70
D. 7.00

35. Which of the following titrations will always have an equivalence point at a pH > 7.00?

A. weak acid with a weak base
B. strong acid with a weak base
C. weak acid with a strong base
D. strong acid with a strong base

36. A buffer solution may contain equal moles of

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

37. A gas which is produced by burning coal and also contributes to the formation of acid rain is

A. H$_2$
B. O$_3$
C. SO$_2$
D. C$_3$H$_8$

**June 2000**

21. The conjugate base of H$_2$PO$_4^-$ is

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

22. Aqua regia is a concentrated aqueous solution of HCl and HNO$_3$. The strongest acid in aqua regia is

A. HCl
B. H$_2$O
C. H$_3$O$^+$
D. HNO$_3$

23. The predominant acid-base reaction between H$_2$O$_2$ and H$_2$O is

A. H$_2$O$_2$ + H$_2$O $\rightarrow$ 3OH$^- + H^+$
B. H$_2$O$_2$ + H$_2$O $\rightarrow$ 2H$_2$O + O$_2$
C. H$_2$O$_2$ + H$_2$O $\rightarrow$ H$_3$O$^+$ + OH$^-$
D. H$_2$O$_2$ + H$_2$O $\rightarrow$ H$_3$O$^+$ + HO$_2^-$
24. Which of the following reactions favours the formation of products?
A. HNO₂ + F⁻ ⇌ HF + NO₂⁻
B. H₂CO₃ + IO₃⁻ ⇌ HIO₃ + HCO₃⁻
C. NH₄⁺ + C₂O₄²⁻ ⇌ HC₂O₄⁻ + NH₃
D. HCN + HCOO⁻ ⇌ HCOOH + CN⁻

25. Which of the following 1.0M solutions will have the lowest [H₃O⁺]?
A. H₂S
B. HNO₂
C. H₂CO₃
D. CH₃COOH

26. In a solution of 0.10M NaCN, the order of ion concentration, from highest to lowest, is
A. [Na⁺] > [OH⁻] > [CN⁻] > [H₃O⁺]
B. [Na⁺] > [CN⁻] > [OH⁻] > [H₃O⁺]
C. [H₃O⁺] > [OH⁻] > [CN⁻] > [Na⁺]
D. [OH⁻] > [Na⁺] > [CN⁻] > [H₃O⁺]

27. What will cause the value of Kᵦ to change?
A. adding OH⁻
B. adding a catalyst
C. decreasing the pH
D. increasing the temperature

28. What is the concentration of Sr(OH)₂ in a solution with a pH = 11.00?
A. 2.0 x 10⁻¹¹
B. 1.0 x 10⁻¹¹
C. 5.0 x 10⁻⁴
D. 1.0 x 10⁻³

29. The Kᵦ expression for HTe⁻ is
A. \( Kᵦ = \frac{[H₂Te][OH⁻]}{[HTe⁻]} \)
B. \( Kᵦ = \frac{[Te²⁺][H₃O⁺]}{[HTe⁻]} \)
C. \( Kᵦ = \frac{[HTe][H₃O⁺]}{[H₂Te]} \)
D. \( Kᵦ = \frac{[HTe][OH⁻]}{[Te²⁺]} \)

30. When comparing 1.0M solutions of bases, the base with the lowest [OH⁻] is the
A. weakest base and it has the largest Kᵦ value.
B. strongest base and it has the largest Kᵦ value.
C. weakest base and it has the smallest Kᵦ value.
D. strongest base and it has the smallest Kᵦ value.

31. The value of Kᵦ for HC₂O₄⁻ is
A. 1.7 X 10⁻¹³
B. 1.6 X 10⁻¹⁰
C. 6.4 X 10⁻⁵
D. 5.9 X 10⁻²

32. Which of the following applies at the transition point for all indicators, HInd?
A. [HInd] = [Ind⁻]
B. [Ind⁻] = [H₃O⁺]
C. $[\text{H}_3\text{O}^+] = [\text{OH}^-]$

D. $[\text{HInd}] = [\text{H}_3\text{O}^+]$

33. Identify the indicator that has a $K_a$ of $1.6 \times 10^{-7}$?

A. methyl red  
B. thymol blue  
C. phenolphthalein  
D. bromthymol blue

34. Which of the following acid solutions would require the smallest volume to completely neutralize 10.00mL of 0.100M NaOH?

A. 0.100M HCl  
B. 0.100M $\text{H}_3\text{PO}_4$  
C. 0.100M $\text{H}_2\text{C}_2\text{O}_4$  
D. 0.100M $\text{CH}_3\text{COOH}$

35. What is the pH of the solution formed when 0.040 mol NaOH (s) is added to 1.00L of 0.050M HCl?

A. 1.30  
B. 1.40  
C. 2.00  
D. 7.00

36. Which of the following titrations will have an equivalence point with a pH less than 7.00?

A. $\text{H}_2\text{SO}_4$ with NH$_3$  
B. HNO$_3$ with LiOH  
C. $\text{H}_3\text{PO}_4$ with KOH  
D. HCOOH with NaOH

37. Which of the following graphs describes the relationship between pH of a buffer solution and a volume of HCl added to the buffer?

A.  
B.  
C.  
D.

August 2000

23. Consider the following equilibrium:
The order of Bronsted-Lowry acids and bases in the reaction is

A. base, acid, acid, base.  
B. base, acid, base, acid.  
C. acid, base, acid, base.  
D. acid, base, base, acid.

24. Which of the following will have the lowest electrical conductivity?

A. 1.00M HCl  
B. 1.00M HNO₃  
C. 1.00M H₂SO₄  
D. 1.00M H₃PO₄

25. Which of the following represents the ionization of water?

A. H₂O → H₂ + ½ O₂  
B. 2H₂O → H₃O⁺ + OH⁻  
C. 2H₂O + O₂ → 2H₂O₂  
D. H₂O → ½ O₂ + 2H⁺ + 2e⁻

26. Which of the following are amphiprotic?

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<td>NH₄⁺</td>
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<td>III</td>
<td>HCO₃⁻</td>
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A. I and II only.  
B. I and III only.  
C. II and III only.  
D. I, II and III.

27. Consider the following equilibrium:

2H₂O (l) + energy → H₃O⁺ (aq) + OH⁻ (aq)

The temperature is increased and a new equilibrium is established. The new equilibrium can be described by

A. pH = pOH and K_w > 1.0 X 10⁻¹⁴  
B. pH = pOH and K_w < 1.0 X 10⁻¹⁴  
C. pH > pOH and K_w = 1.0 X 10⁻¹⁴  
D. pH < pOH and K_w = 1.0 X 10⁻¹⁴

28. What is the pH of a 0.10M Sr(OH)₂ solution?

A. 0.70  
B. 1.00  
C. 13.00  
D. 13.30

29. In order to change the pH of a solution from 2.0 to 4.0 the [H₃O⁺] must

A. increase by a factor of 2.  
B. decrease by a factor of 2.  
C. increase by a factor of 100.  
D. decrease by a factor of 100.

30. The K_b expression for HSe⁻ is

[H₂Se][OH⁻]  
[HSe⁻]
A. K_b = --------------
31. Which of the following graphs describes the relationship between $K_a$ and $K_b$ for all conjugate pairs?

A. 

![Graph A](image)

B. 

![Graph B](image)

C. 

![Graph C](image)

D. 

![Graph D](image)

32. The value of $K_b$ for HSO$_3^-$ is

A. $6.7 \times 10^{-13}$
B. $1.5 \times 10^{-13}$
C. $1.0 \times 10^{-7}$
D. $1.5 \times 10^{-2}$

33. Which of the following ions will produce an acidic solution when added to water?

A. O$_2^-$
B. Na$^+$
C. NH$_4^+$
D. HCO$_3^-$

34. What is the $[H_3O^+]$ at the transition point for an indicator with a $K_a$ of $3.9 \times 10^{-8}$?

A. $1.0 \times 10^{-14}$ M
B. $3.9 \times 10^{-8}$ M
C. $1.0 \times 10^{-7}$ M
D. $2.6 \times 10^{-7}$ M

35. What is the pH of the solution formed when 0.040mol KOH is added to 2.00L of 0.020M HCl?

A. 0.00
B. 7.00
C. 12.00
D. 12.30

36. The pH of normal rainwater is a result of the presence of dissolved

A. SO$_2$
### Answer Key

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