Hydrolysis / Chemical Indicators: Practice Problems.

1. Which of the following substances is a salt that produces a basic aqueous solution?
   a. KBr
   b. NH₃
   c. NH₄Cl
   d. Na₃PO₄

2. An indicator, HInd, is found to establish the following equilibrium:

   HInd(aq) ⇌ H⁺(aq) + Ind⁻(aq)

   When the indicator was added to solutions of various pH values, the following data were collected:

<table>
<thead>
<tr>
<th>pH</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>colour</td>
<td>yellow</td>
<td>yellow</td>
<td>yellow</td>
<td>yellow</td>
<td>green</td>
<td>blue</td>
</tr>
</tbody>
</table>

   At pH 10,
   a. [H⁺] = K_a
   b. [H⁺] = pH
   c. [H⁺] = [Ind⁻]
   d. [H⁺] = [HInd]

3. Which of the following will have the greatest [H₃O⁺]?
   a. 0.10 M NaF
   b. 0.10 M NaIO₃
   c. 0.10 M Na₂SO₃
   d. 0.10 M NaCH₃COO
4. A solution of unknown pH is tested with various indicators resulting in the following data:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>methyl violet</td>
<td>blue</td>
</tr>
<tr>
<td>bromcresol green</td>
<td>blue</td>
</tr>
<tr>
<td>methyl red</td>
<td>yellow</td>
</tr>
<tr>
<td>bromthymol blue</td>
<td>yellow</td>
</tr>
<tr>
<td>phenolphthalein</td>
<td>colourless</td>
</tr>
</tbody>
</table>

From the above data, the pH of the solution is approximately
a. 1.6
b. 5.4
\(\text{c. } 6.0\)
d. 8.2

5. Consider the following data:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Color of Acid form</th>
<th>Color of Base form</th>
<th>(K_a) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>'A'</td>
<td>red</td>
<td>yellow</td>
<td>(1.0 \times 10^{-3})</td>
</tr>
<tr>
<td>'B'</td>
<td>yellow</td>
<td>blue</td>
<td>(1.0 \times 10^{-9})</td>
</tr>
</tbody>
</table>

At a pH of 7.0, the predominant color of
\(\text{a.}\) indicator 'A' and indicator 'B' will both be yellow.
\(\text{b.}\) indicator 'A' will be red and indicator 'B' will be yellow.
\(\text{c.}\) indicator 'A' will be yellow and indicator 'B' will be blue.
\(\text{d.}\) indicator 'A' will be orange and indicator 'B' will be green.

6. The approximate \(K_a\) value for the indicator thymolphthalein is
\(\text{a.}\) \(1 \times 10^{-10}\)
\(\text{b.}\) \(1 \times 10^{-4}\)
\(\text{c.}\) 4
\(\text{d.}\) 10
7. The value of $K_b$ for $\text{HSO}_3^-$ is
   (a) $6.7 \times 10^{-13}$
   b. $6.2 \times 10^{-8}$
   c. $1.6 \times 10^{-7}$
   d. $1.7 \times 10^{-2}$

8. Two indicators were added to separate samples of a solution, giving the following results:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophenol red</td>
<td>Red</td>
</tr>
<tr>
<td>Thymol blue</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

The pH of the solution is approximately
   a. 3
   b. 5
   c. 7
   d. 10

9. Find the pOH and pH of the following solutions.
   a. $0.50 \text{ M KCN}$ $\quad \text{pOH} = 2.50 \quad \text{pH} = 11.50$
   b. $1.0 \text{ M Na}_2\text{CO}_3 \quad \text{pOH} = 1.87 \quad \text{pH} = 12.13$
   c. $0.05 \text{ M NaC}_6\text{H}_5\text{COO} \quad \text{pOH} = 5.56 \quad \text{pH} = 8.44$
   d. $0.2 \text{ M AlCl}_3 \quad \text{pOH} = 11.22 \quad \text{pH} = 2.78$

10. When a $0.1 \text{ M}$ solution of $\text{NH}_3$ is titrated against a $0.1 \text{ M}$ solution of $\text{HCl}$, the endpoint is reached at pH 5.1. Which indicator would be best to use in the titration of $\text{NH}_3$ with $\text{HCl}$? methyl red or brom cresol green

11. Calculate the $[\text{OH}^-]$ midway through the colour change (or transition point) for the indicator indigo carmine.

   $[\text{OH}^-] = \frac{0.014 \text{ M}}{0.02 \text{ M}} = 0.02 \text{ M}$

12. When the amphiprotic anion, $\text{HPO}_4^{2-}$, is added to water, does it act as an acid or as a base? Support your answer with calculations.

   $K_a = 2.2 \times 10^{-13}$

   $K_b = \frac{1.0 \times 10^{-6}}{6.2 \times 10^{-8}} = 1.6 \times 10^{-7}$

   $K_a > K_b$ is basic

13. A $0.60 \text{ M}$ base solution, $\text{NaX(aq)}$, is found to have a $[\text{OH}^-]$ of $0.12 \text{ M}$. Determine the $K_b$ for the base.

   $K_b = \frac{[\text{OH}^-][\text{X}^-]}{[\text{NaX}]} = \frac{(0.12)(0.12)}{0.6} = 3.0 \times 10^{-2}$

14. Discuss, in terms of hydrolysis, the use of sodium acetate to produce the vinegar flavour on some potato chips.

   $\text{NaCH}_3\text{COO} \rightarrow \text{Na}^+ + \text{CH}_3\text{COO}^-$  \hspace{1cm} \text{CH}_3\text{COOH is the acid in vinegar.}$

   $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \leftrightarrow \text{CH}_3\text{COOH} + \text{OH}^-$