The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

**Model 1: pH**

<table>
<thead>
<tr>
<th>pH</th>
<th>0.50</th>
<th>1.50</th>
<th>2.50</th>
<th>3.50</th>
<th>4.50</th>
<th>5.50</th>
<th>5.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>([H_3O^+(aq)])</td>
<td>(3.2 \times 10^{-1})</td>
<td>(3.2 \times 10^{-2})</td>
<td>(3.2 \times 10^{-3})</td>
<td>(3.2 \times 10^{-4})</td>
<td>(3.2 \times 10^{-5})</td>
<td>(3.2 \times 10^{-6})</td>
<td>(1.8 \times 10^{-6})</td>
</tr>
</tbody>
</table>

2. The part of the pH value before the decimal point controls the position of the decimal point in the concentration. The part of the pH value after the decimal point affects the number itself. The number of significant figures is controlled by the number of decimal places in the pH value.

3. \(p_{K_w} = -\log_{10}K_w = -\log_{10}(1.0 \times 10^{-14}) = 14\) at 25 °C.

**Model 2: Strong and Weak Acids**

1. The major species present are \(H_3O^+(aq)\), \(Cl^-(aq)\) and \(H_2O(l)\). There is essentially no “\(HCl(aq)\)”.

2. The major species present are \(CH_3COOH(aq)\) and \(H_2O(l)\). The percentage ionization is very small and there is very little \(H_3O^+(aq)\), \(CH_3COO^-(aq)\).

3. \(CH_3COO^-(aq)\) is the dominant species only at high pH.

4. \(CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO(aq)\)
   \[K_a = \frac{[H_3O^+(aq)][CH_3COO^-(aq)]}{[CH_3COOH(aq)]}\]

5. The major species present are \(CH_3NH_2(aq)\) and \(H_2O(l)\).

6. \(CH_3NH_3^+(aq)\) is the dominant species only at low pH.

7. (a) Aspirin is absorbed in the stomach. In the intestine, it is deprotonated.
(b) Amphetamine is absorbed in the intestine. In the stomach, it is protonated.

**Model 3: Conjugate Pairs**

1. (a) \(OH^-\) (b) \(H_3O^+\)
2. (a) \(CH_3COO^-\) (b) \(NH_3\) (c) \(CH_3CH_2CH_2NH_2\)
3. (a) \(H_3S^+\) (b) \(H_2S\) (c) \(HS^-\)

**CHEM1002 Worksheet 8 – Answers to Critical Thinking Questions**

**CHEM1002** 2010-N-4  November 2010

- Hydrochloric acid in a healthy human stomach leads to a pH in the range 1-2. What is the concentration of hydrochloric acid in the stomach?

HCl is a strong acid so is completely dissociated in solution: the concentration of HCl is equal to \([H_3O^+(aq)]\).

Using \(pH = -\log_{10}[H_3O^+(aq)]\):

\[ [H_3O^+(aq)] = 10^{-pH} = 10^{-1} = 0.1 \text{ when the pH is 1 and} \]
\[ [H_3O^+(aq)] = 10^{-pH} = 10^{-2} = 0.01 \text{ when the pH is 2} \]
The structure of methyl 4-aminobenzoate, \((E)\), is given below.

\[
\begin{align*}
\text{(E)} & \\
\begin{array}{c}
\text{a} \\
\text{b}
\end{array}
\end{align*}
\]

Give the structure(s) of all organic products formed when compound \((E)\) is treated with the following reagents. If no reaction occurs, write “NO REACTION”.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>cold HCl (1 M)</td>
<td>No hydrolysis of the ester under these conditions. The amine group will be protonated by the strong acid.</td>
</tr>
<tr>
<td>hot NaOH (4 M)</td>
<td>Treatment with base will lead to hydrolysis of the ester. In the basic solution, the carboxylic acid will be deprotonated and the amine will not be protonated.</td>
</tr>
<tr>
<td>hot HCl (4 M)</td>
<td>Hydrolysis of ester. In acidic conditions, the carboxylic acid will not be deprotonated and the amine group will be protonated.</td>
</tr>
</tbody>
</table>