Experiment 14  The action of a buffer solution

Aim

The purpose of the experiment is to compare the effects of adding small amounts of acid and alkali to buffered and unbuffered solutions of the same pH.

Introduction

You are provided with a buffer solution designed to maintain a pH of 7.0 at 25 °C and some pure water which, if it is pure enough, should also have a pH of 7.0 at 25 °C.

To sample of these two liquids you add small measured amounts of 0.25 M NaOH and 0.25 M HCl, measuring the pH at each addition.

By comparing the pH changes in the two solutions you can demonstrate the action of a buffer solution.

Procedure

1. Fill a burette with 0.25 M HCl and another with 0.25 M NaOH.
2. Using a measuring cylinder, put 25 cm³ of the buffer solution in a 50 cm³ beaker.
3. Rinse the pH meter electrode with distilled water from a wash bottle, and put it into the beaker, making sure that the glass bulb is completely immersed. Set the meter to read 7.0.
4. Place the beaker under the burette containing NaOH and, making sure the alkali does not fall directly to ensure thorough mixing and record the pH in a copy of Results Table.
   If you cannot use a pH meter, measure the pH by transferring 1 drop of the mixed solution on a glass rod to a piece of pH paper. Use full-range paper first, and then narrow-range paper to obtain a more accurate value.
5. Add more NaOH to make the total volume added 1.0 cm³; measure and record the pH as before.
6. Add more NaOH to make the total volume added 5.0 cm³; measure and record the pH. Rinse the electrode in distilled water and stand it in a flask of distilled water.
7. Take another 25 cm³ portion of the buffer, and measure the pH on the addition of 1 drop, 1.0 cm³, and 5.0 cm³ of 0.25 M HCl in the same way as you did for NaOH. Again, rinse the electrode carefully and stand it in distilled water.
8. Put 25 cm³ of pure water in the beaker and, keeping its exposure time to the air as short as possible, measure its pH. If it is absolutely pure, its pH will be 7.0, but it is very difficult to achieve this. If the pH is less than 6.0, wash the beaker and electrode more carefully and try again.
9. When you have a pH between 6.0 and 7.0 for the ‘pure’ water, measure and record the pH changes on addition of 0.25 M NaOH and 0.25 M HCl just as you did for the buffer solution. Take special care to wash the electrode when you change from using alkali to acid. Record your results in Results Table.
10. Take another 25 cm³ of pure water, measure the pH and then leave it to stand open to the air for ten minutes. Measure the pH again and record the results.
Results Table

<table>
<thead>
<tr>
<th>Volume added</th>
<th>pH on addition of 0.25 M NaOH to</th>
<th>pH on addition of 0.25 M HCl to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>buffer</td>
<td>buffer</td>
</tr>
<tr>
<td></td>
<td>pure water</td>
<td>pure water</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 drop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 cm³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0 cm³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH of pure water with minimum air exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH of pure water after 10 mins air exposure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions

1. By how much (to the nearest unit) does the pH of 25 cm³ of pure water change for the addition of 1.0 cm³ of 0.5 M HCl ?

2. Calculate the ratio: \( \frac{[H^+(aq)] \text{ after addition of 1.0 cm}^3 \text{ of HCl to pure water}}{[H^+(aq)] \text{ in pure water}} \)

3. What must have happened to most of the hydrogen ions added to the buffer ?

4. Why does the pH of pure water decrease when exposed to the air ?