Investigation 17.B: Preparing a Buffer and Investigating its Properties Answer Key

Answers to Predictions

(a) 40.0 mL of 0.20 mol/L NaOH(aq) is required to neutralize 40.0 mL of 0.20 mol/L ethanoic acid.

(b) 20.0 mL of 0.20 mol/L NaOH(aq) is required to prepare a buffer solution with 40.0 mL of 0.20 mol/L ethanoic acid.

(c) Your estimate should indicate that the buffer is acidic.

(d) $$[\text{NaOH(aq)}] = \frac{1\times10^{3}\ \text{L}\times0.20\ \text{mol/L}}{0.021\ \text{L}}$$

$$= 9.5\times10^{-3}\ \text{mol/L}$$

Therefore, $[OH^-(aq)] = 9.5 \times 10^{-3}$ mol/L
pOH = 2.02; pH = 11.98

(e) Your estimate should indicate that the pH of the buffer solution changes very little. The pH may rise slightly, but the solution should still be acidic.

(f) The calculation is very similar:
$[HCl(aq)] = 9.5 \times 10^{-3}$ mol/L
Therefore, $[H_3O^+(aq)] = 9.5 \times 10^{-3}$ mol/L
pH = 2.02.
The pH of the buffer solution may fall slightly, but it should change very little.

Answers to Analysis Questions

1. The distilled water may be acidic due to dissolved carbon dioxide. This should not be a problem in this activity because the amount of carbonic acid present will be very small.

2. The pH of the water will become lower. Blowing air into the water will increase the amount of dissolved carbon dioxide, and therefore the concentration of carbonic acid.

$CO_2(aq) + H_2O(\ell) \leftrightarrow H_2CO_3(aq)$
$H_2CO_3(aq) + H_2O(\ell) \leftrightarrow H_3O^+(aq) + HCO_3^-(aq)$

3. The pH of the buffer will change very little as a result of blowing air through the solution.

4. The most likely reason for any difference will be an inaccurate measurement of the volume of base added.

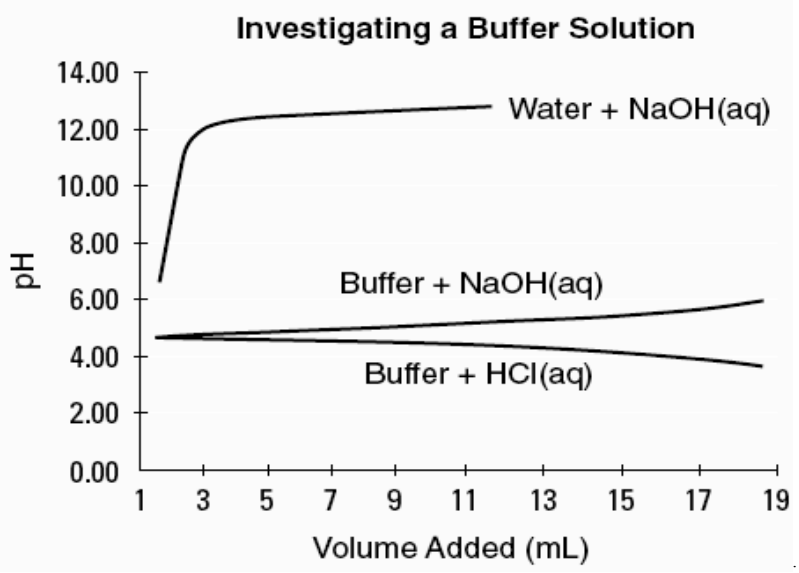
5. Initially, the pH of the buffer should be equal to the pK_a of ethanoic acid, 4.7. The measured pH of the buffer may differ from the estimated pH for a number of reasons. If the difference is large, check to make sure the volumes used to make the buffer were calculated correctly. Smaller differences are likely due to errors in the measurement of the volume of acetic acid or the volume of sodium hydroxide, or both.

Investigation 17.B: Preparing a Buffer and Investigating its Properties Answer Key (continued)

6. The following is typical data:

Volume of NaOH(aq) added (mL)	pH of water + added NaOH(aq)	pH of buffer + NaOH(aq)	pH of buffer + HCl(aq)
0.0	7.00	4.74	4.74
1.0	11.98	4.78	4.72
2.00	12.26	4.83	4.69
3.00	12.42	4.87	4.67
4.00	12.52	4.92	4.64
5.00	12.60	4.96	4.62
6.00	12.66	5.01	4.59
7.00	12.71	5.06	4.55
8.00	12.76	5.11	4.52
9.00	12.79	5.16	4.48
10.00	12.82	5.22	4.44
11.00		5.28	4.39
12.00		5.34	4.34
13.00		5.41	4.28
14.00		5.49	4.22
15.00		5.59	4.14
16.00		5.69	4.04
17.00		5.83	3.92
18.00		6.02	3.74

This data is shown graphically in the figure below. The buffer resists change in pH when acid or base is added. By comparison, the effect of adding base to pure water is a sudden and large increase in pH.



Investigation 17.B: Preparing a Buffer and Investigating its Properties Answer Key (continued)

Answer to Conclusion Question

7. Adding a small amount of an acid or base to a buffer changes the pH of the solution by only a very small amount.

Answer to Extension Question

8. A basic pH buffer solution could be prepared by mixing aqueous ammonia with a solution of an ammonium salt, such as ammonium chloride.