Investigation 8.C: Standardizing a Hydrochloric Acid Solution Answer Key

Answers to Analysis Questions

1. (a) You should demonstrate your calculations clearly for your answer to this question.
Sample answer:

$$v_{average} = \frac{13.60\,\text{mL} + 13.65\,\text{mL} + 13.70\,\text{mL}}{3} = 13.65\,\text{mL}$$

(b) Performing multiple trials allows you to use average volumes in calculations. This diminishes the effect of random errors.

2. $$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2CO_3(aq)$$

OR

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(\ell) + CO_2(g)$$

3. Your answer should be close to the value of 0.125 mol/L that was prepared. Assuming that the mass of the sodium carbonate used to make the standard solution is 0.90 g, and using the average volume of HCl(aq) of 13.65 mL, a sample calculation is as follows:

$$c_{HCl} = \frac{0.90\text{ g } Na_2CO_3}{105.99\,\frac{\text{g}}{\text{mol}}} \times \frac{10.00\,\text{mL}}{100.0\,\text{mL}} \times \frac{2\text{ mol HCl}}{1\text{ mol } Na_2CO_3} \times \frac{1000\text{ mL}}{1\text{ L}} \times \frac{1}{13.65\text{ mL}}$$

$$c_{HCl} = 0.124\,\frac{\text{mol}}{\text{L}}$$

4. Any results outside the range of 0.120 to 0.130 mol/L should be discarded. The rest of the class results should be averaged and used as the concentration for Investigation 8.D.

Answers to Conclusion Questions

5. The class average should be reasonably close to the value of 0.125 mol/L.

6. In general, the class average should be relatively close to the actual value of 0.125 mol/L, as the greater the number of values used to calculate the class average, the more accurate the average becomes (one of the reasons scientists carry out multiple trials). One common source of error is failing to discard unreasonable results prior to calculating average volumes.

7. Possible sources of error include:
- inaccurate judgment of end point
- inaccurate pipetting
- inaccurate reading of burette
- spillage and contamination of solution
- inadequate time to gather data from enough trials to minimize sources of error

Answer to Extension Question

8. Sodium carbonate, also known as washing soda, enhances the effectiveness of surfactants (detergents) by maintaining a basic environment in the washing machine. A basic environment prevents the minerals in hard water from reacting with the surfactants to form a sludgy precipitate.