Equivalence Point

The point at which the two solutions used in a titration are present in chemically equivalent amounts is the **equivalence point.** Indicators and pH meters can be used to determine the equivalence point. A pH meter will show a large pH change occurring at the equivalence point. If an indicator is used, it must change color over a range that includes the pH of the equivalence point, as shown in **Figure 8.** *The point in a titration at which an indicator changes color is called the* **end point** *of the indicator.*

Some indicators, such as litmus, change color at about pH 7. However, the color-change interval for litmus is broad, pH 5.5–8.0. This broad range makes it difficult to determine an accurate pH. Bromthymol blue is better because it has a limited transition interval, pH 6.2–7.6 (see **Table 6**). Indicators that undergo transition at about pH 7 are used to determine the equivalence point of strong-acid/strong-base titrations because the neutralization of strong acids with strong bases produces a salt solution with a pH of 7.

Indicators that change color at pH lower than 7 are useful in determining the equivalence point of strong-acid/weak-base titrations. Methyl orange is an example of this type. The equivalence point of a strong-acid/weak-base titration is acidic because the salt formed is itself a weak acid. Thus the salt solution has a pH lower than 7.

Indicators that change color at pH higher than 7 are useful in determining the equivalence point of weak-acid/strong-base titrations. Phenolphthalein is an example. These reactions produce salt solutions whose pH is greater than 7. This occurs because the salt formed is a weak base.

You may be wondering what type of indicator is used to determine the equivalence point of weak-acid/weak-base titrations. The surprising answer is "none at all." The pH of the equivalence point of weak acids and weak bases may be almost any value, depending on the relative strengths of the reactants. The color transition of an indicator helps

CAREERS in Chemistry

Analytical Chemist

The primary job of an analytical chemist is to obtain information by making precise measurements. Analytical chemists often use sophisticated, state-of-the-art instruments to analyze for barely detectable amounts of materials. In addition to collecting data, analytical chemists must process the data and communicate their findings with others. These findings must be the result of careful and reproducible work, strict accountability, and control of the samples. Although analytical chemists work in all areas of chemistry, one important area is environmental chemistry, which involves analyzing air, water, and soil samples. The results of these tests are used by regulatory agencies such as the Environmental Protection Agency.

(a) (b)

FIGURE 8 Indicators change color at the end point of a titration. Phenolphthalein (a) turns pink and methyl red (b) turns red at the end point of these titrations with a base.