Determination of concentration of standard solution of potassium permanganate through measurement of end point of oxidation-reduction reaction using UV-Vis spectroscope

Oxidation-reduction reaction, like acid-base reaction, occurs quantitatively, and thus can be utilized as a volume analysis method to find the concentration of a specimen. This experiment can find the concentration of the materials contained in the specimen by measuring the amount necessary to oxidize or reduce the specimen completely with an oxidizer or reducer solution of known concentration. This method yields a far more accurate result value than the bare-eye observation of the color changes of the indicator.

Potassium permanganate is a strong oxidizer, and is widely used as the primary standard to titrate iron (II). Since it is difficult to obtain this material in a pure state, it is impossible to create a solution of an accurate concentration by measuring the mass of the reagent, so it must be standardized. In most cases, it contains a small amount of manganese dioxide, so it is standardized with primary standards such as sodium oxalate, oxalic acid, arsenic trioxide, or pure iron.

This experiment intends to find the actual concentration of the potassium permanganate standard solution of by titrating potassium permanganate in an acidic solution with sodium oxalate as the primary standard.

The corresponding oxidation-reduction equation is as follows.

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

The total number of electrons from the oxidation process is the same as the total number of electrons from the reduction process, so

$$nMv = n'M'v'$$

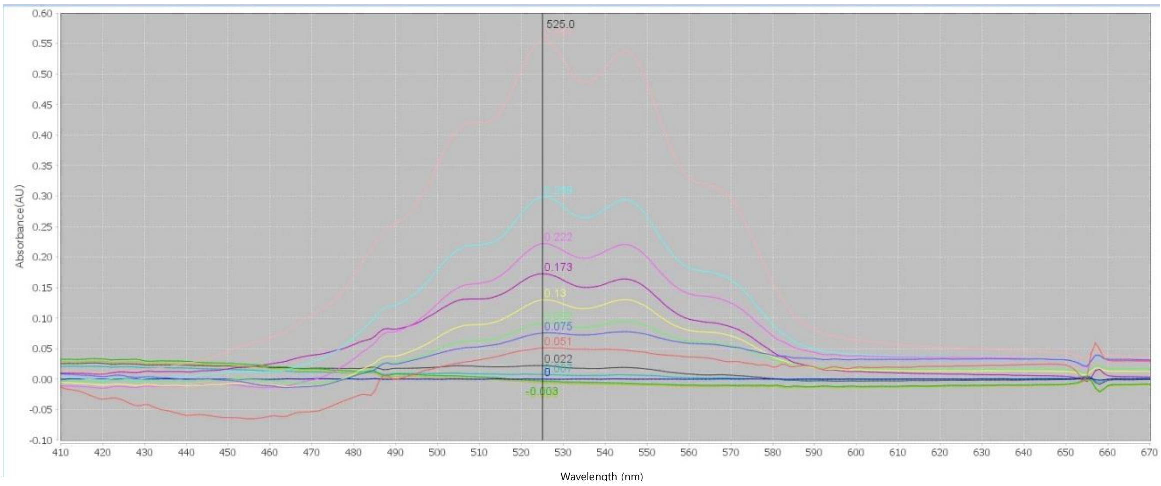
n, number of reacting electrons per 1 mole of each specimen

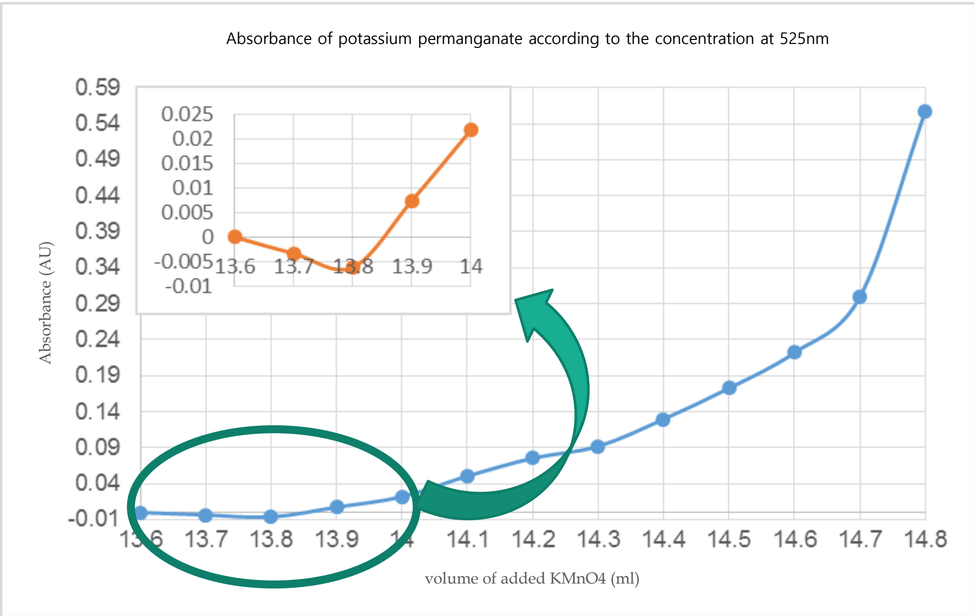
M, Mole concentration of each specimen

v, volume of titrated solution

Using the above equation, the concentration of potassium permanganate standard solution is determined.

The end point of the oxidation-reduction reaction is the point where the color changes from none to purple or pink when potassium permanganate is added to the transparent solution dissolved with the acidic sodium oxalate.





At the end point of the reaction, the potassium permanganate, which is the oxidizer in excess, completely oxidizes the sodium oxalate, and the amount increases so that the red-colored manganese gradually increases the absorbance value of the entire reacting solution.

According to the above graph, the end point is when 13.8~ 13.9 ml of potassium permanganate is added, so through calculation with the standard solution concentration equation, the sodium oxalate solution dissolves 0.01g of sodium oxalate in the solvent where 100ml of distilled water is added to 6M H_2SO_4 10ml;
so the mole concentration of sodium oxalate is

$$\frac{0.1 \text{ g}/\ 133.999 \text{ g}\ /\text{mole}}{0.11\ L} = 0.0067843\ M$$

The volume of the reacted sodium oxalate is 0.11L, and the volume of potassium permanganate added at the end point is about 13.9ml. From the reaction equation, the number of electrons for reduction of potassium permanganate is 5, and the number of electrons for oxidation of sodium oxalate is 2, so the calculation of

5 X concentration of potassium permanganate standard solution X titration volume= 2 X mole concentration of sodium oxalate X titration volume

results in the actual concentration of potassium permanganate standard solution being 0.021475. As 0.8g of potassium permanganate to be titrated was to be dissolved in 250ml of distilled water to generate 0.02M, with the absorbance value by the actual oxidation-reduction reaction, the accurate standard solution concentration of potassium permanganate is 0.021475.

The titration using the absorbance of UV-Vis spectroscope can detect the change in absorption rate of the solution by a very small amount of micro-unit, so that it can be useful for accurate and precise data analysis.