Analytical techniques

1 *In which order are these analytical procedures dealt with in the following passage?*

- ☐ Colorimetric analysis
- ☐ Conductimetric analysis
- ☐ Pressure measurements
- ☐ Titrimetric analysis

The rate of a chemical reaction can be obtained by following some properties which alter with the extent of the reaction. By analysing the reaction mixture at suitable intervals, it is possible to determine the concentration of both reactants and products at different times and hence obtain a measure of the reaction rate (i.e. the rate at which the concentration of a particular substance changes with time).

The choice of analytical method depends on the reaction under consideration. The following techniques illustrate four possible approaches.

One method is particularly suitable for reactions in solution. The reaction can be followed by removing and analysing small portions of the reaction mixture at intervals. Very often, the removed portion must be added to some reagent which will stop the reaction (i.e. "quench" it), thereby preventing further changes in concentration before the analysis is carried out. The quenched mixture can then be analysed by titrating the substance.

Another method is especially convenient for those systems in which one of the substances is coloured. The intensity of colour can be followed during the reaction using a photoelectric colorimeter, and from these measurements the concentration of the coloured species can be obtained at different times.

Many reactions in aqueous solution involve ions and changes in the number of ions present as the reaction proceeds. Consequently, the electrical conductivity of the solution will change during the reaction and this can be used to determine the changing concentrations of reactants and products with time. Essentially, this consists in immersing two inert electrodes in the reaction mixture and then following the change in electrical conductivity of the solution with time.

A fourth technique is particularly suitable for reactions in the gas phase which involves changes in pressure when the system is kept in a vessel of constant volume. The pressure is measured at suitable time intervals.

The last three methods have one great advantage over titrimetric analysis in that samples need not be removed from the reacting mixture. In these three cases, the extent of the reaction is determined at intervals of time by an external method without disturbing the reaction mixture.

It is important to realize that measurements on the reacting system do not give the rate of reaction directly; they simply give the concentration of a particular reactant or product, X, at a given time, t. By plotting a graph of the concentration of X against time, it is possible to determine the reaction rate (i.e. the change in concentration of X with time, d[X]/dt) from the gradient of the tangent at a given point.

(from: Hill-Hollman, *Chemistry in Context*, Nelson)

2 *Answer these questions about* Analytical techniques.

a. How can the rate of a chemical reaction be measured?
b. What analytical methods are used to measure reaction rates?
c. What reactions is titrimetric analysis most suitable for?
d. What apparatus is used in colorimetric analysis?
e. How is conductimetric analysis carried out?
f. What reactions are pressure measurements most convenient for?