1. For each of the following problems indicate whether its solution requires a qualitative analysis, a quantitative analysis, a characterization analysis, or a fundamental analysis. More than one type of analysis may be appropriate for some problems.

   a. A hazardous-waste disposal site is believed to be leaking contaminants into the local groundwater.
   b. An art museum is concerned that a recent acquisition is a forgery.
   c. Airport security needs a more reliable method for detecting the presence of explosive materials in luggage.
   d. The structure of a newly discovered virus needs to be determined.
   e. A new visual indicator is needed for an acid–base titration.
   f. A new law requires a method for evaluating whether automobiles are emitting too much carbon monoxide.

2. Read the article “When Machine Tastes Coffee: Instrumental Approach to Predict the Sensory Profile of Espresso Coffee,” by several scientists working at the Nestlé Research Center in Lausanne, Switzerland. You will find the article on pages 1574-1581 in Volume 80 of Analytical Chemistry, published in 2008. Write an essay summarizing the nature of the problem and how it was solved. As a guide, refer to Figure 1.3 for a model of the analytical approach to solving problems.

   Note

   Use this link to access the article’s abstract from the journal’s web site. If your institution has an on-line subscription you also will be able to download a PDF version of the article.

1.4.3 Solutions to Practice Exercises

Literature Exercise 1.1

What is the analytical problem and why is it important?

A medical diagnoses often relies on the results of a clinical analysis. When visiting a doctor, he or she may ask the nurse to draw a sample of your blood and send it to the lab for analysis. In some cases the result of the analysis is available in 10-15 minutes. What is possible in a developed country, such as the United States, may not be feasible in a country with fewer resources because lab equipment is expensive, and because there may be a shortage of trained personnel to run the tests and to interpret the results. The problem addressed in this paper, therefore, is the development of a reliable device for rapidly and quantitatively performing clinical assays in less than ideal circumstances.

What criteria did the authors consider in designing their experiments?

In considering solutions to this problem, the authors identify seven important criteria for the device: it must be inexpensive; it must operate without the need for much electricity, so that it can be taken to remote sites; it must be adaptable to many types of assays; its operation must not require a highly skilled technician; it must be quantitative; it must be accurate; and it must produce results rapidly.
What is the basic experimental procedure?

The authors describe the development of a paper-based microfluidic device that allows anyone to run an analysis by dipping the device into a sample (synthetic urine, in this case). The sample moves by capillary action into test zones containing reagents that react with specific species (glucose and protein, for this prototype device). The reagents react to produce a color whose intensity is proportional to the species' concentration. Digital pictures of the microfluidic device are taken with a cell phone camera and sent to an off-site physician who analyzes the picture using image editing software and interprets the assay's result. (This is an example of a colorimetric method of analysis. Colorimetric methods are covered in Chapter 10.)

What interferences were considered and how did they overcome them?

In developing this analytical method the authors considered several chemical or physical interferences. One concern was the possibility of non-specific interactions between the paper and the glucose or protein, which could lead to non-uniform image in the test zones. A careful analysis of the distribution of glucose and protein in the test zones showed that this was not a problem. A second concern was the possible presence in samples of particulate materials that might interfere with the analyses. Paper is a natural filter for particulate materials and the authors found that samples containing dust, sawdust, and pollen did not interfere with the analysis for glucose. Pollen, however, is an interferent for the protein analysis, presumably because it, too, contains protein.

How did the authors calibrate the assay?

To calibrate the device the authors analyzed a series of standard solutions containing known concentrations of glucose and protein. Because an image's intensity depends upon the available light, a standard sample is run with the test samples, which allows a single calibration curve to be used for samples collected under different lighting conditions.

How did the authors validate their experimental method?

The test device contains two test zones for each analyte, allowing for duplicate analyses and providing one level of experimental validation. To further validate the device, the authors completed 12 analyses at each of three known concentrations of glucose and protein, obtaining acceptable accuracy and precision in all cases.

Is there any evidence of repeating steps 2, 3, and 4?

Developing this analytical method required several repetitive paths through steps 2, 3, and 4 of the analytical approach. Examples of this feedback loop include optimizing the shape of the test zones, and evaluating the importance of sample size.

In summary, the authors report the successful development of an inexpensive, portable, and easy-to-use device for running clinical samples in developing countries. Click here to return to the chapter.

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