PROBLEM 2.32

A **hygrometer**, which measures the amount of moisture in a gas stream, is to be calibrated using the apparatus shown here (figure on p. 36 of the text). Steam and dry air are fed at known flow rates and mixed to form a gas stream with a known water content, and the hygrometer reading is recorded; the flow rate of either the water or the air is changed to produce a stream with a different water content and the new reading is recorded, and so on. The following data are taken for y (mass fraction of water in the combined stream) vs. R (the hygrometer reading):

R	5	20	40	60	80
y	0.011	0.044	0.083	0.126	0.169

(a) Draw a calibration curve and determine an equation for $y(R)$.

(b) Suppose a sample of a stack gas is inserted in the sample chamber of the hygrometer and a reading of $R = 43$ is obtained. If the mass flow rate of the stack gas is 1200 kg/h, what is the mass flow rate of the water vapor in the stack gas?

Strategy

The information about the hygrometer, the flowchart, and the description of the experiment (and similar information in other problems) are there to acquaint you with the kinds of systems and situations you may encounter as a chemical engineer. Don't let them confuse you, however. If you carefully examine what you are being asked to do in this problem, you will see that you just need to (a) plot values of y against values of R and find an equation relating the two variables, then (b) substitute for R and calculate y.

The only way to fit an equation to data using the methods presented in this book is to find a way of plotting the data to get a straight line, then find the equation of the line. (There are more sophisticated ways involving *non-linear regression* that we won't discuss.) The simplest case occurs if the two variables are linearly related, $y = aR + b$. To determine whether they are, we will plot y vs. R and if a straight line can reasonably be drawn through the data points (which will turn out to be the case in this problem) we'll go from there.

Solution

(a) Draw a calibration curve and determine an equation for $y(R)$.
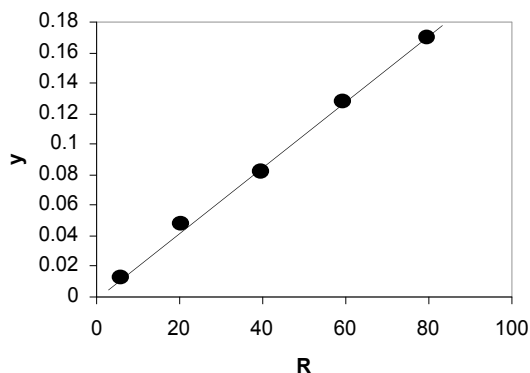
A plot of y vs. R on rectangular coordinates is a line through $(R = 5,\ y = 0.011)$ and $(R = 80,\ y = 0.169)$. (Two other points could equally well have been chosen, leading to slightly different results.)