

A. G. Williamson
University of Otago
Dunedin, New Zealand

Simple Method for Determining Number of Theoretical Plates

Most laboratory experiments in fractional distillation are based on the determination of the number of theoretical plates in a column (or series of columns) from analyses of the distillate and of the residue. It is possible in principle to obtain the same information directly from measurements of the equilibrium temperatures at the top and bottom of a fractionating column. The number of theoretical plates is then obtained by drawing steps on a temperature-composition diagram between two temperatures instead of between two compositions as in the usual method.

In practice the use of temperature measurements limits the choice of systems to those for which there is a measurable change in boiling point per theoretical plate over a reasonably broad section of the boiling-point composition diagram. A brief search of the literature reveals a number of such systems. The one used in this laboratory is the system benzene + chloroform, for which there is a temperature change of between 0.5 and 2°C per plate over a range of about nine theoretical plates (Fig. 1). This is quite suitable for experiments on columns 10–12 in. long, filled with common packings.

The experiment as carried out in this laboratory uses the apparatus shown in Figure 2. Simple insulation is required on the columns. It would be an improvement to use vacuum-jacketted columns as this would enable students to observe the behavior of the column at and near the flooded condition. The thermometers are

calibrated using the boiling point of one of the pure components of the mixture. A mixture of the appropriate composition is then introduced to the boiler, the apparatus is brought to equilibrium, and the temperatures at the top and bottom of the column are measured. Students observe the range of boiling rates for which constant temperatures are obtained and the behavior of the column and thermometers when flooding occurs.

The experiment is repeated for each of several kinds of packing and students are asked to comment on the factors which appear to influence the efficiency of a column. The construction for obtaining the number of theoretical plates for the rod and disc packing is shown by the dotted lines in Figure 1. This construction gives a total of five theoretical plates. One of the equilibration steps will be in the boiler itself, so that the number of plates in the column is four.

Typical results for three types of packing follow:

Packing type	Temp. at top of column (°C)	Temp. at bottom of column (°C)	No. of plates
Empty tube	75.4	71.9	ca. 1
Rod and disc	78.0	70.3	4
1/8 in. glass spheres	78.1	66.7	5 1/2

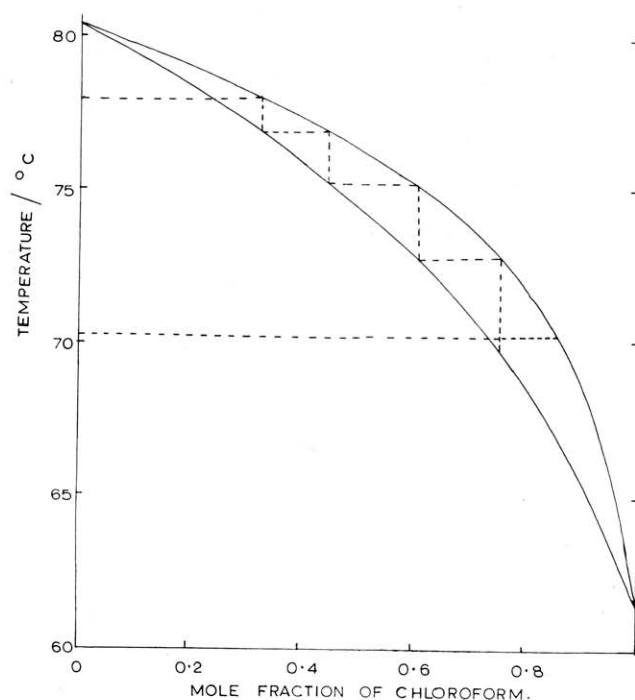


Figure 1.

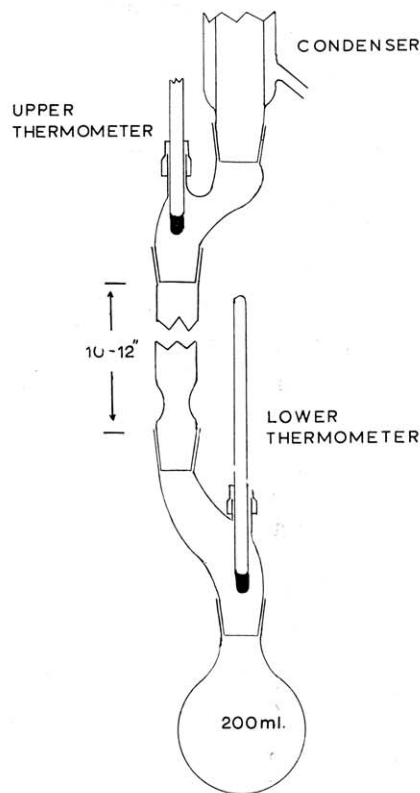


Figure 2.