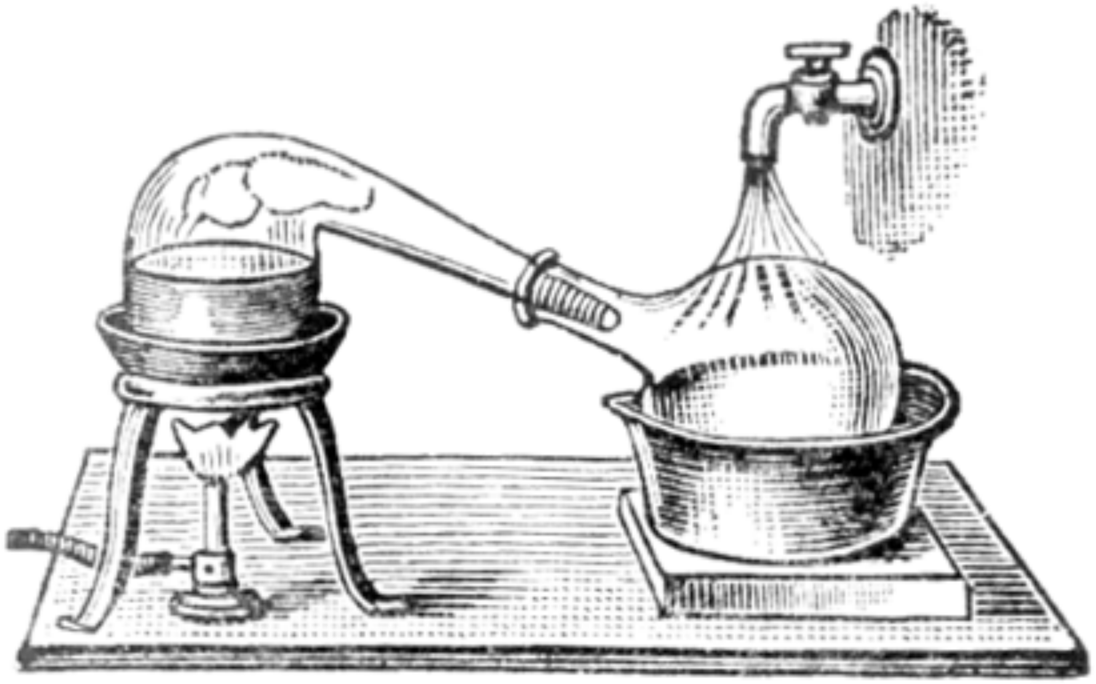
Week 3: Distillation I



Best way to separate a mixture of two liquids

Simple Distillation

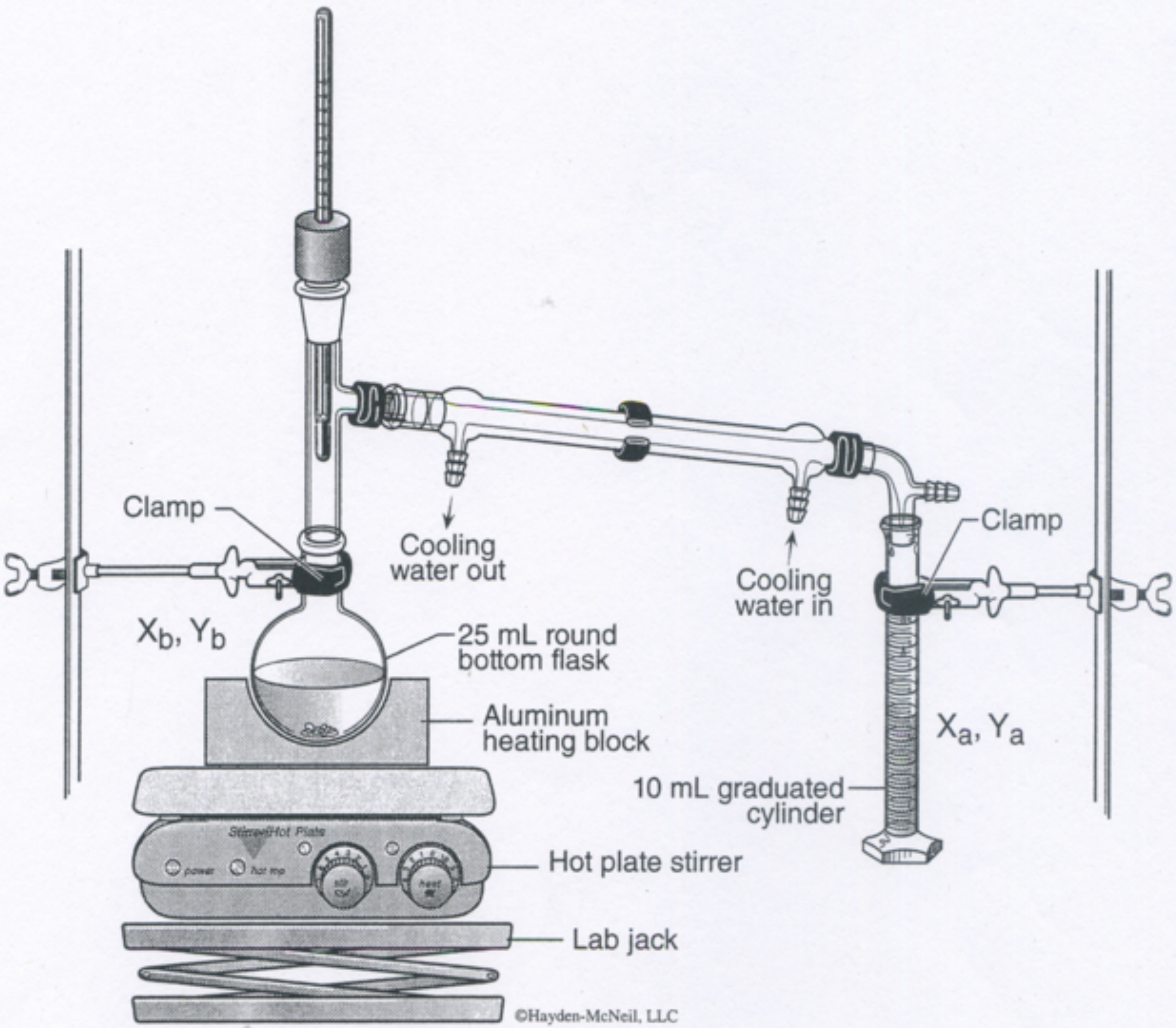


Figure 3.3. A simple distillation setup.

Simple Distillation = 1 evaporation / condensation

1 Simple Distillation = 1 Theoretical Plate

Simple vs Fractional Distillation

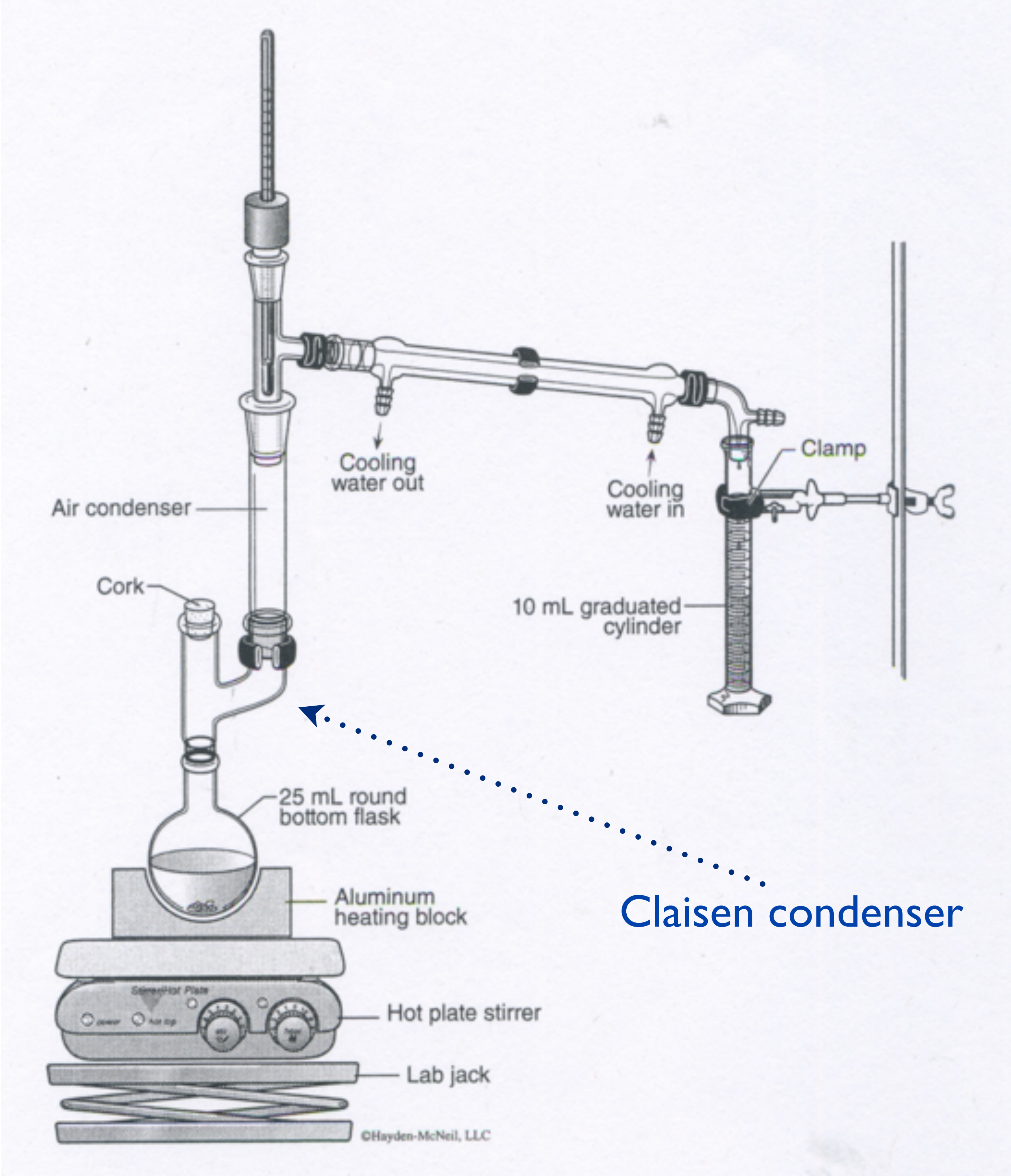
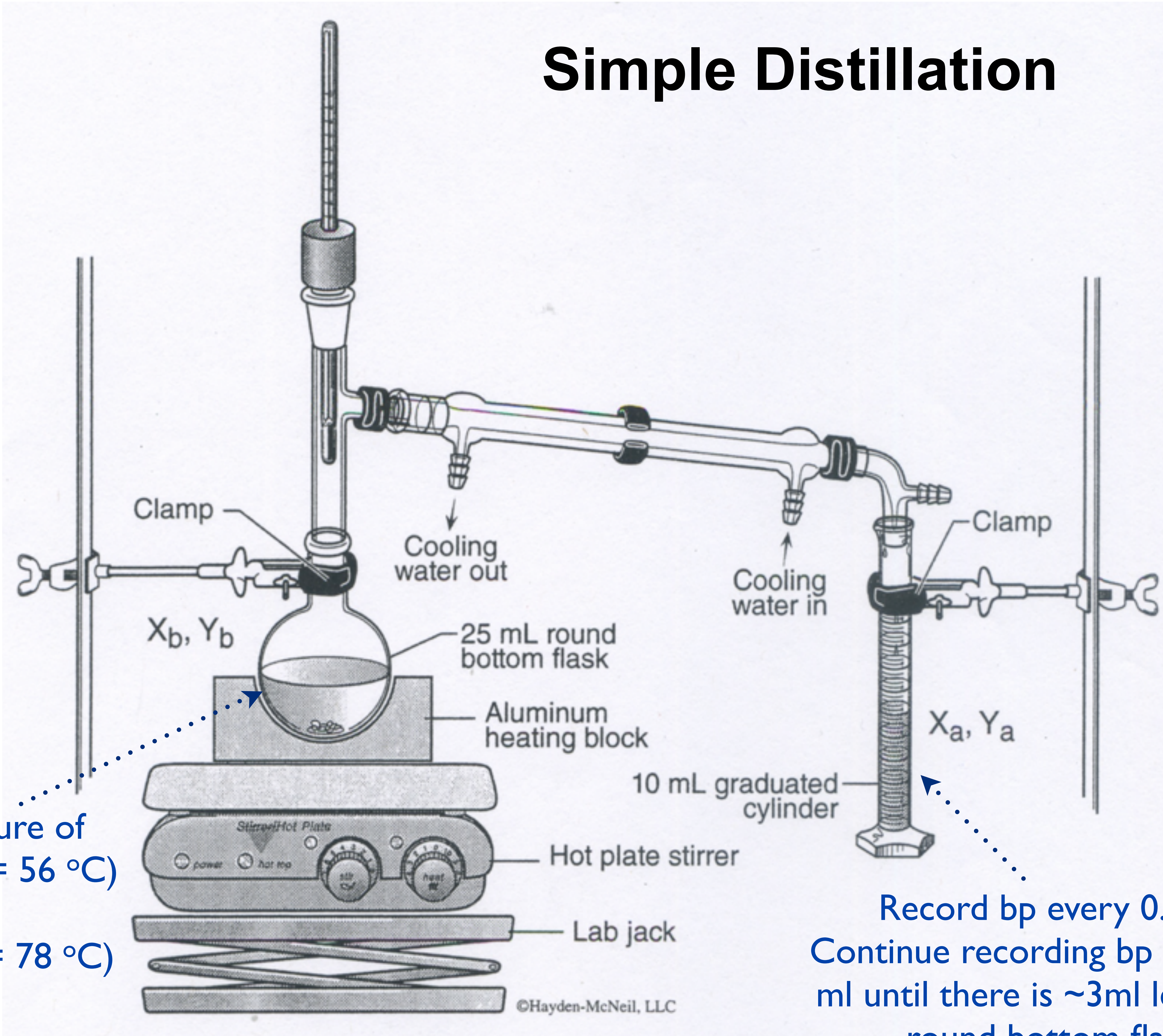


Figure 3.4. A fractional distillation setup.

1 Fractional Distillation = >1 Theoretical Plates

Fractional Distillation is more efficient than the Simple Distillation.

Simple Distillation



14 ml mixture of acetone (bp = 56 °C) and ethanol (bp = 78 °C)

Record bp every 0.4 ml
Continue recording bp every 0.4 ml until there is ~3ml left in the round bottom flask.

Fractional Distillation

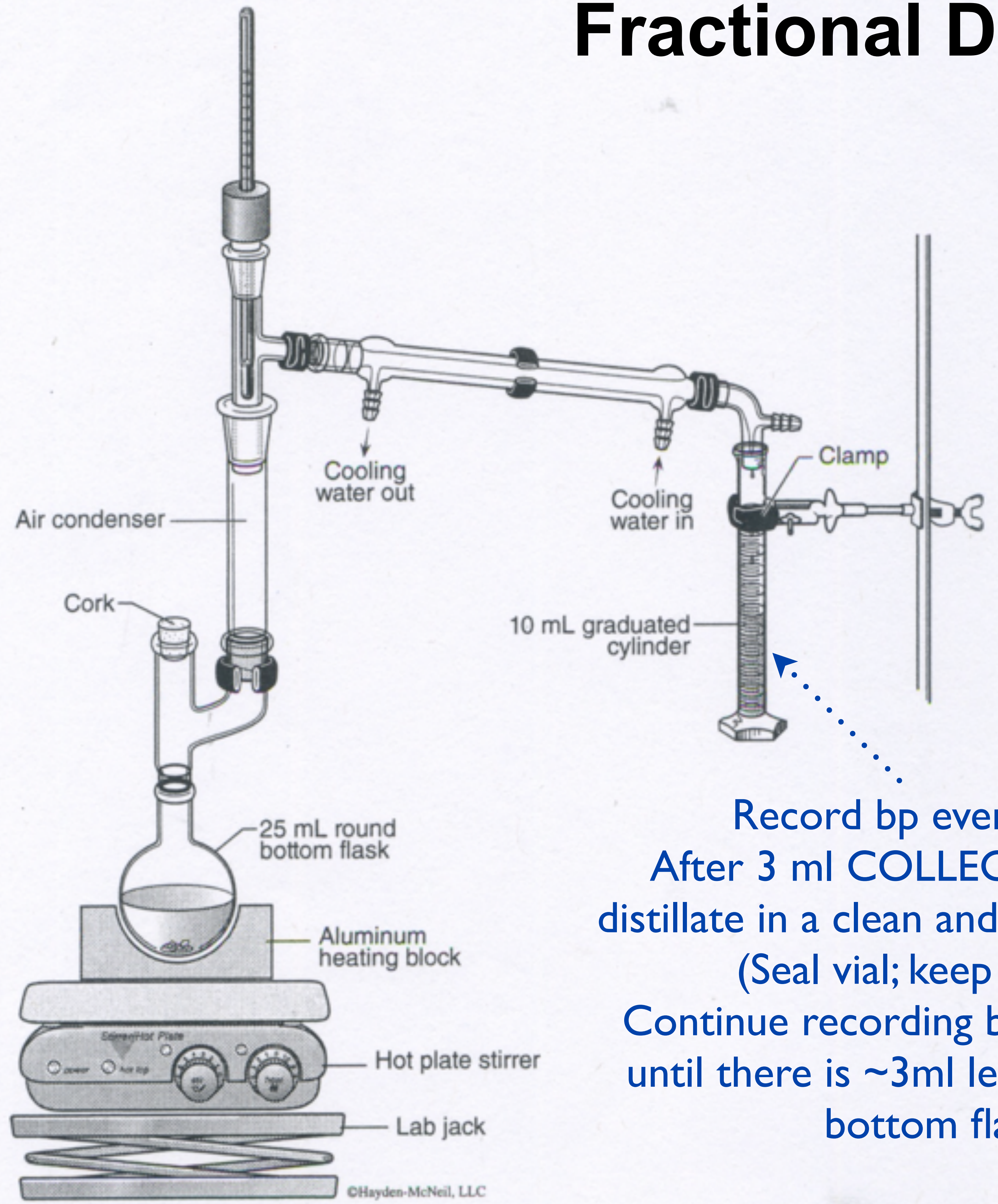
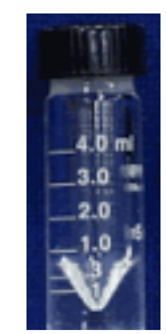


Figure 3.4. A fractional distillation setup.

Record bp every 0.4 ml
After 3 ml COLLECT 5 drops of distillate in a clean and dry conical vial.
(Seal vial; keep for GC)
Continue recording bp every 0.4 ml until there is ~3ml left in the round bottom flask.



Graphing Your Data

Report your data as below:

Simple Distillation		Fractional Distillation	
Volume (mL)	Temp. (°C)	Volume (mL)	Temp. (°C)
1.0	52.2		
1.2	52.2		
1.6	52.3		
1.8	52.4		
8.0	??		

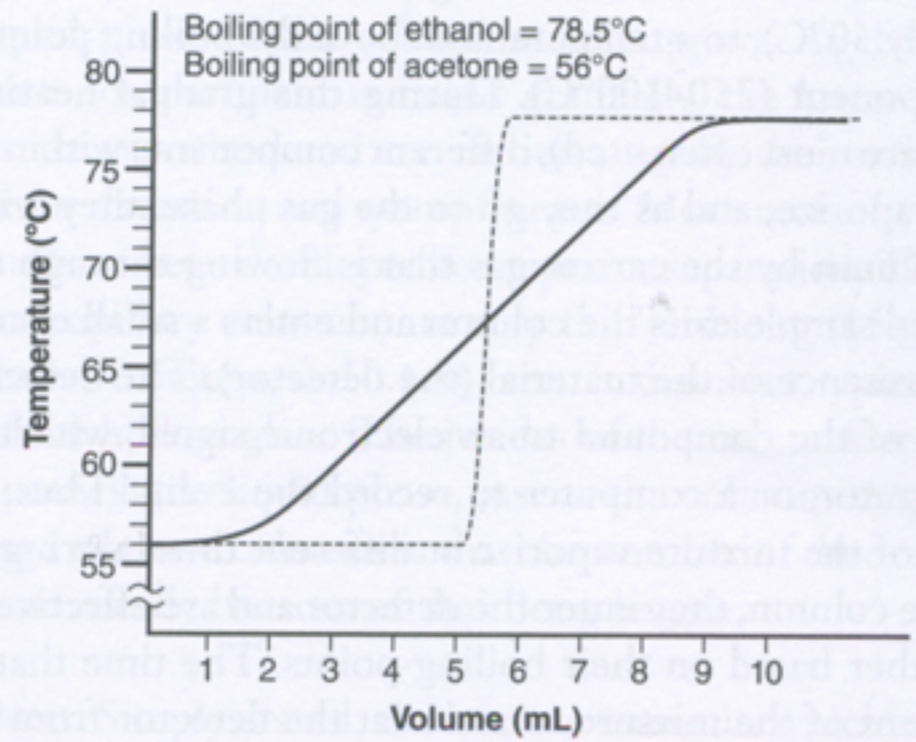


Figure 3.1. Separation of an equimolar mixture of acetone/ethanol by distillation. The boiling points for the pure components are 56 and 78.5°C for acetone and ethanol, respectively. The dashed line graphs the distillation setup with an infinite number of theoretical plates.

CAUTION: Be careful, as both acetone and ethanol are highly flammable solvents.

Calculating Number of Theoretical Plates

The Fenske equation can be used to calculate the number of theoretical plates in a particular piece of apparatus. For a simple two-compound system the Fenske equation can be written as:

$$n = \frac{\log\left(X_a / X_b\right) - \log\left(Y_a / Y_b\right)}{\log\alpha}$$

n = number of theoretical plates.

X_a = The vapor pressure of the more volatile compound in the product (acetone).

X_b = The vapor pressure of the more volatile compound in the distilling flask (acetone).

Y_a = The vapor pressure of the less volatile compound in the product (ethanol).

Y_b = The vapor pressure of the less volatile compound in the distilling flask (ethanol).

α = vapor pressure ratio of the two components.

Gas Chromatography

Column "**A**" is packed with 20% carbowax 20M on Chromasorb P AW DMCS, 80/100 mesh.

Column "**B**" is packed with 20% DC-200 20M on Chromasorb P AW DMCS, 80/100 mesh.

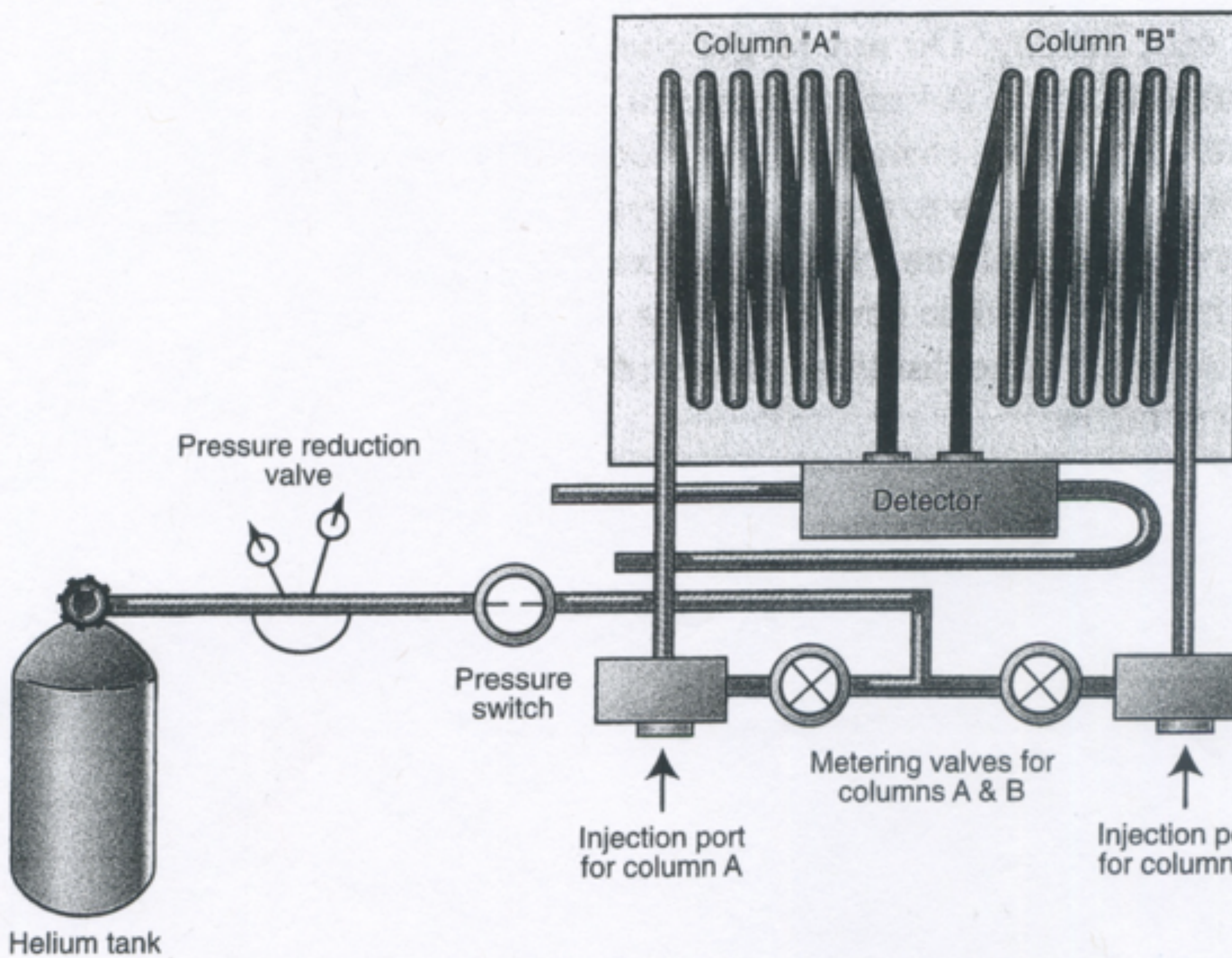
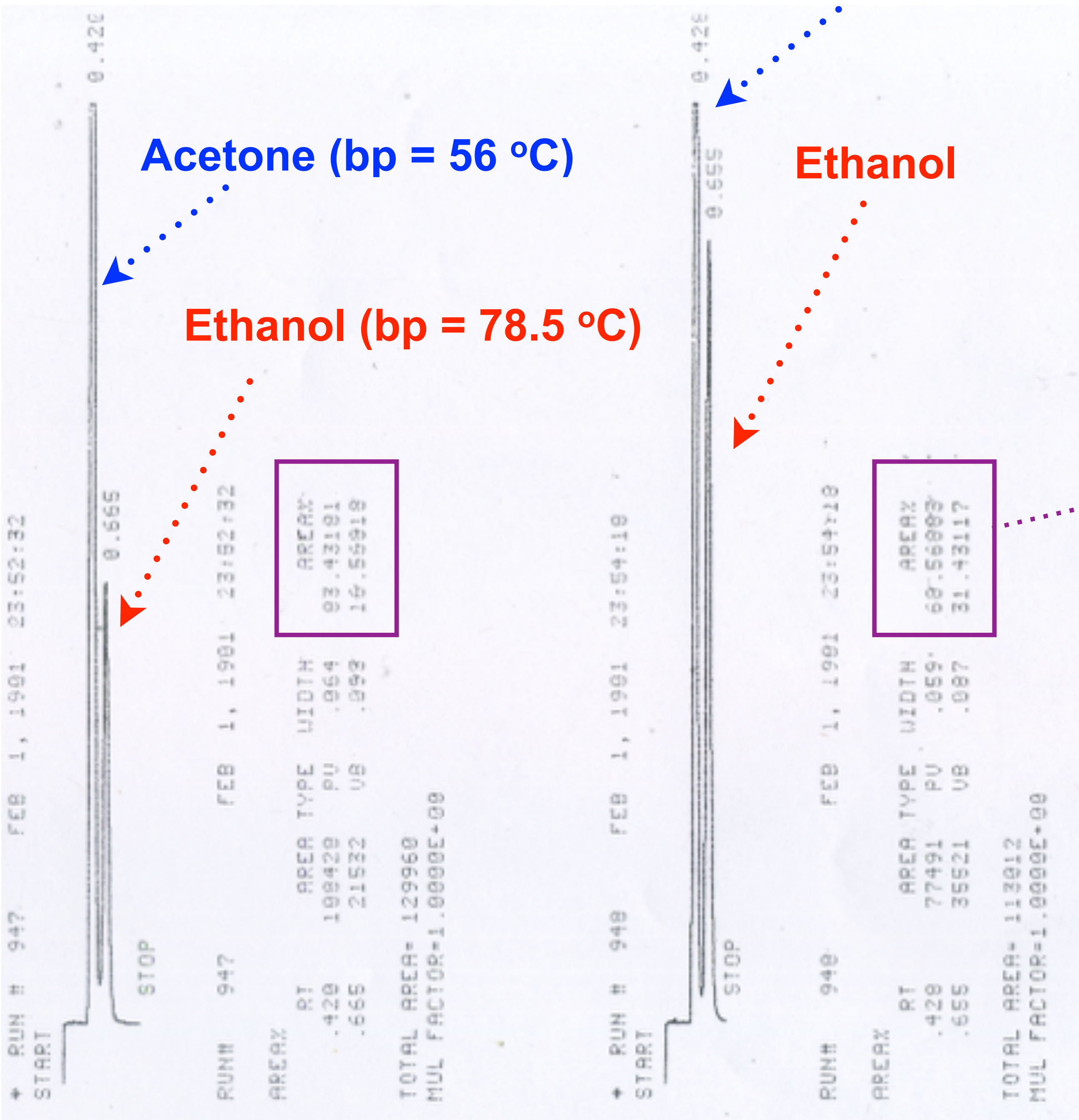


Figure 3.2. Schematic diagram of a GOW-MAC GC

Calculating Number of Theoretical Plates

GC Chromatograph



1st Fraction

2nd Fraction

The Fenske equation can be used to calculate the number of theoretical plates in a particular piece of apparatus. For a simple two-compound system the Fenske equation can be written as:

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n = number of theoretical plates.

X_a = The vapor pressure of the more volatile compound in the product (acetone).

X_b = The vapor pressure of the more volatile compound in the distilling flask (acetone).

Y_a = The vapor pressure of the less volatile compound in the product (ethanol).

Y_b = The vapor pressure of the less volatile compound in the distilling flask (ethanol).

α = vapor pressure ratio of the two components.

Area %
68.6 Acetone → X_a
31.4 Ethanol → Y_a

X_b, Y_b will be provided by your TA
i.e. $X_b = 52$, $Y_b = 48$

alpha= 1.7

n = [log (68.6/52) - log(31.4/48)] / log1.7

n = 1.35