Week 3: Distillation I

Best way to separate a mixture of two liquids
Simple Distillation

Simple Distillation = 1 evaporation / condensation

1 Simple Distillation = 1 Theoretical Plate

Figure 3.3. A simple distillation setup.
Simple vs Fractional Distillation

1 Fractional Distillation = >1 Theoretical Plates

Fractional Distillation is more efficient than the Simple Distillation.
Record bp every 0.4 ml
Continue recording bp every 0.4 ml until there is ~3ml left in the round bottom flask.

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

<table>
<thead>
<tr>
<th>Simple Distillation</th>
<th>Fractional Distillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (mL)</td>
<td>Volume (mL)</td>
</tr>
<tr>
<td>Temp. (°C)</td>
<td>Temp. (°C)</td>
</tr>
<tr>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

8.0

?!?

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**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:

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

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

\[ n = \text{number of theoretical plates.} \]

\[ X_a = \text{The vapor pressure of the more volatile compound in the product (acetone).} \]

\[ X_b = \text{The vapor pressure of the more volatile compound in the distilling flask (acetone).} \]

\[ Y_a = \text{The vapor pressure of the less volatile compound in the product (ethanol).} \]

\[ Y_b = \text{The vapor pressure of the less volatile compound in the distilling flask (ethanol).} \]

\[ \alpha = \text{vapor pressure ratio of the two components.} \]
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

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:

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

where:
- \( n \) is the number of theoretical plates.
- \( X_a \) is the vapor pressure of the more volatile compound in the product (acetone).
- \( X_b \) is the vapor pressure of the more volatile compound in the distilling flask (acetone).
- \( Y_a \) is the vapor pressure of the less volatile compound in the product (ethanol).
- \( Y_b \) is the vapor pressure of the less volatile compound in the distilling flask (ethanol).
- \( \alpha \) is the vapor pressure ratio of the two components.

Give the values of \( X_b, Y_b \) will be provided by your TA.

i.e. \( X_b = 52, Y_b = 48 \)

\[ \alpha = 1.7 \]

\[
n = \frac{\log \left( \frac{68.6}{52} \right) - \log \left( \frac{31.4}{48} \right)}{\log 1.7}
\]

\[ n = 1.35 \]