Lab Experiment 2: Purifying Chemicals by Discussion
30 January 2018
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Procedure

See laboratory manual page 20 to 27
One minor adjustment was made to protocol:
- A piece of aluminum foil was added around the distilling flask and extension clamp to speed up the heating process.

Observations

Simple Distillation:
- Liquid began to evaporate at 51.3°C - the boiling point of more volatile component, 2-propanol
- As temperature increased, more of the liquid was distilled
- Peak temperature was 83.3°C, the boiling point of 1-butanol
- We started off with 25mL of liquid, but only 23 mL was distilled – considering the clips we used were loose, some of the vapour must have escape (source of error)
- Temperature increased gradually until it peaked and ended with drastic decrease

Simple Distillation Data

Volume (mL of distillate collected)	Temperature (°C)
1	51.3
2	53.9
3	57.8
4	60.0
5	61.0
6	62.0
7	62.5
8	66.4
9	67.6
10	68.5
11	68.9
12	68.5
13	68.9
14	71.6
15	73.5
16	75.9
17	79.3

18	81.5
19	83.2
20	83.3
21	81.0
22	78.3
23	68.1
24	-
25	-

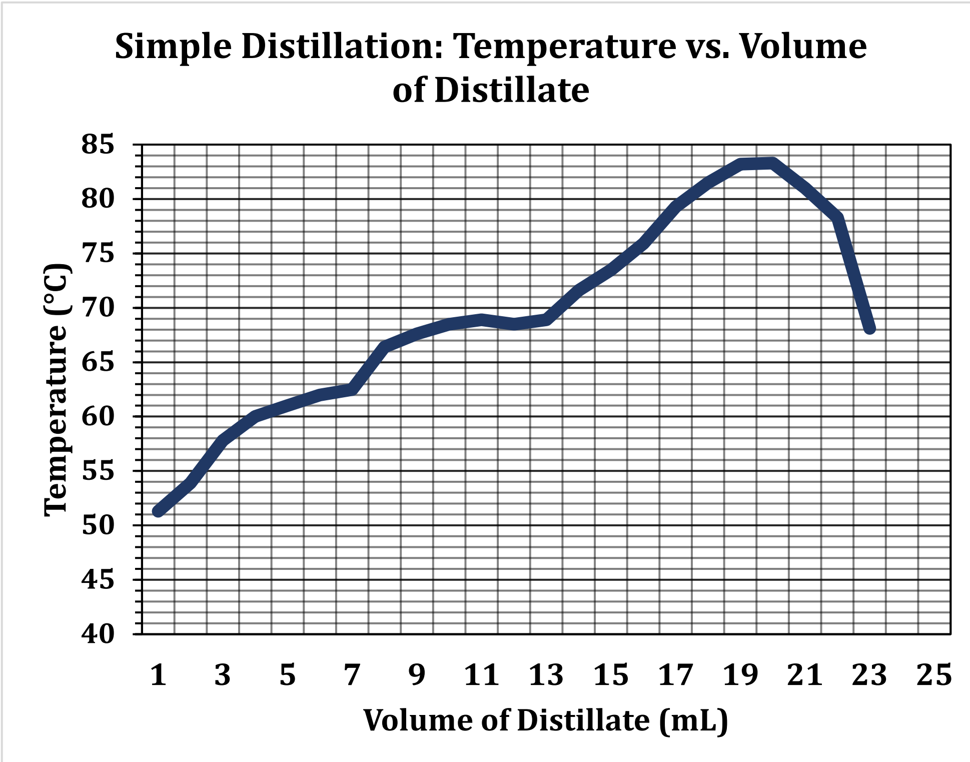
Fractional Distillation:

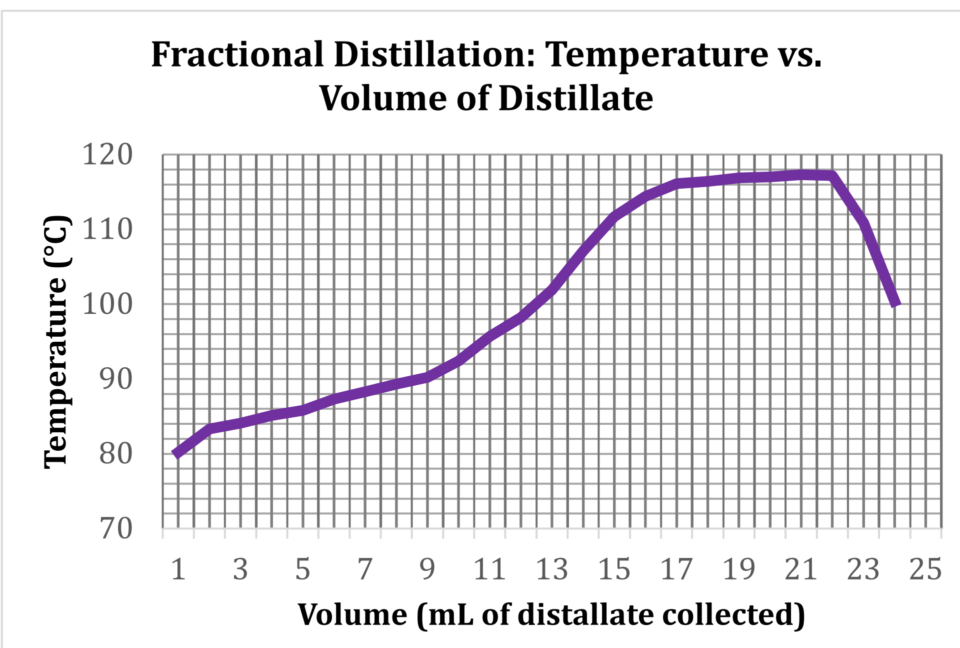
- Liquid began to evaporate at 80.2°C - the boiling point of 2-propanol, the more volatile component
- Significant spike in temperature at 19 mL where temperature hit 116.1°C, boiling point of 1-butanol
- Started off with 25 mL, ended with 24 mL – liquid evaporated through loose clips
- Temperatures plateaued around 117.0°C

Fractional Distillation Data

Volume (mL of distillate collected)	Temperature (°C)
1	80.2
2	83.3
3	84.1
4	85.1
5	85.8
6	87.3
7	88.3
8	89.3
9	90.2
10	92.4
11	95.7
12	98.2
13	101.9
14	107.1
15	111.7
16	114.4
17	116.1
18	116.4
19	116.9
20	117.0
21	117.3
22	117.2
23	110.9
24	100.4
25	-

Graphs


Simple Distillation: Temperature vs. Volume of Distillate
85
80
75
70
65
60
55
50
45
40
Temperature (°C)
1 3 5 7 9 11 13 15 17 19 21 23 25
Volume of Distillate (mL)


Fractional Distillation: Temperature vs. Volume of Distillate
120
110
100
90
80
70
Temperature (°C)
1 3 5 7 9 11 13 15 17 19 21 23 25
Volume (mL of distallate collected)

Discussion

- The graphs of temperature vs. volume on both the simple and fractional distillation are fairly similar. They both have a slow gradual increase in temperature until a certain point is reached, then there is a significant jump in temperature.
- This slow, gradual increase in temperature is an indicator of the molecule with the lowest boiling point, in this case it is the 2-proponal at 83°C. In the fractional distillation, this is shown, however, on the simple distillation graph it indicates that the boiling point of 2-propanol is 51.3°C. This difference in boiling point is probably due to the digital thermometer malfunctioning - a possible source of error.
- The jump in temperature indicates the higher boiling point of 1-butanol, 118°C. However, in the simple distillation, the boiling point of 1-butanol is 83.3°C, this is incorrect.
- The curves of both of the graphs should of have plateaued in the beginning showing the distillation of 2-propanol, however, in the above graphs, there is a gradual increase.
- In the fractional distillation, the graph did plateau when it reached the boiling point of 1-butanol showing the distillation of the substance, but in the simple distillation, there was no plateau at the higher boiling point; as soon as the temperature hit 118°C, it decreased immediately. This is an error, as there should be plateau where 1-butanol distilled.
- The fractional distillation had a greater spike in temperature or jump in the graph and this is because fractional distillation provides a purer separation of liquids.
- The graph of fractional distillation is supposed to have a greater jump in temperature and have a distinct curve. In opposition, the graph of the simple distillation is supposed to be more linear and have less of a curve.
- Our errors may have caused our data and our graphs to have deferred from the correct results.

Questions

1) Liquid must be flowing back through the fractionating column in order to get an adequate separation of the liquid components. The vapour in the fractionating column will condense and then the heat will cause the re-vaporization of the component with the lower boiling point. The evaporated component will move upward, while the component with the higher boiling point will condense and move downward, back into the distilling flask. This allows for a purer separation.

2) The reason for maintaining a uniform temperature gradient in the fractionating column is that the liquid needs to become vapour and travel up the column before being condensed in the condenser and collected in the receiving flask. If there is too little heat, then the liquid will condense before reaching the condenser and move downward into the distilling flask. If there is too much heat, then there is the possibility that the liquid will not be separated purely: component B will evaporate along will component A. A uniform temperature gradient is necessary to ensure proper distillation.

3) The normal boiling point of a liquid is the temperature where the vapour pressure is equal to the atmospheric pressure. Thus, the vapour pressure of benzene at its boiling point (81°C) is equal to the standard atmospheric pressure which is 1 atm or 760 mm Hg.

4) An increase in atmospheric pressure would cause an increase the boiling point. An increase in pressure would push molecules closer together resulting in a stronger attractive force. To break the molecules apart it would take more energy, hence a higher boiling point.

5) Cooling water entering the bottom of the condenser helps prevent the formation of air bubbles. If water enters from the top, the flow can be disrupted causing only sections of the condenser to be cooled, effecting the overall distilling. With water entering from the bottom, the entire chamber must be filled before expelling excess water, allowing more efficient condensation.

6) P_A= 350 mm Hg
P_B = 150 mm Hg

Both compounds are at 95°C

$P_{Total} = \frac{3}{4}(350\ mm\ Hg) + \frac{1}{4}\ (150\ mm\ Hg)$
= 300 mm Hg

∴ the vapor pressure of the mixture of compound A and B at 95°C would be 300 mmHg

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Simple Distillation

∅ 24.7

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1	51.3
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Fractional Distillation

Volume (mL)	Temperature (°C)
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25	