Experiment 2 - Purifying Chemicals by Distillation

Procedure:

- See laboratory manual page 20 to 27
- We were asked to only collect 12.5 mL of each condensed solution, and I was not able to obtain further data from my TA, therefore I was only able to plot my graphs based on the data points I had, but I am able to make inferences on what they should look like.

Observations:

- **Simple Distillation:**
    - 50:50 mixture of 2-propanol and 1-butanol is a clear, transparent, colourless solution.
    - Aluminum foil and a slightly higher level of heat was needed because the temperature was not rising fast enough.
    - The condensed solution was also clear, transparent, and colourless.
    - It took about 10-15 minutes for the distillation to be complete
- **Fractional Distillation:**
    - 50:50 mixture of 2-propanol and 1-butanol is a clear, transparent, colourless solution.
    - Aluminum foil and a slightly higher level of heat was needed because the temperature was not rising fast enough.
    - The condensed solution was also clear, transparent, and colourless.
    - It took about 20 minutes for the distillation to be complete.

Tables:

- **Simple Distillation**

Volume Condensed (mL)	**Temperature (°C)**

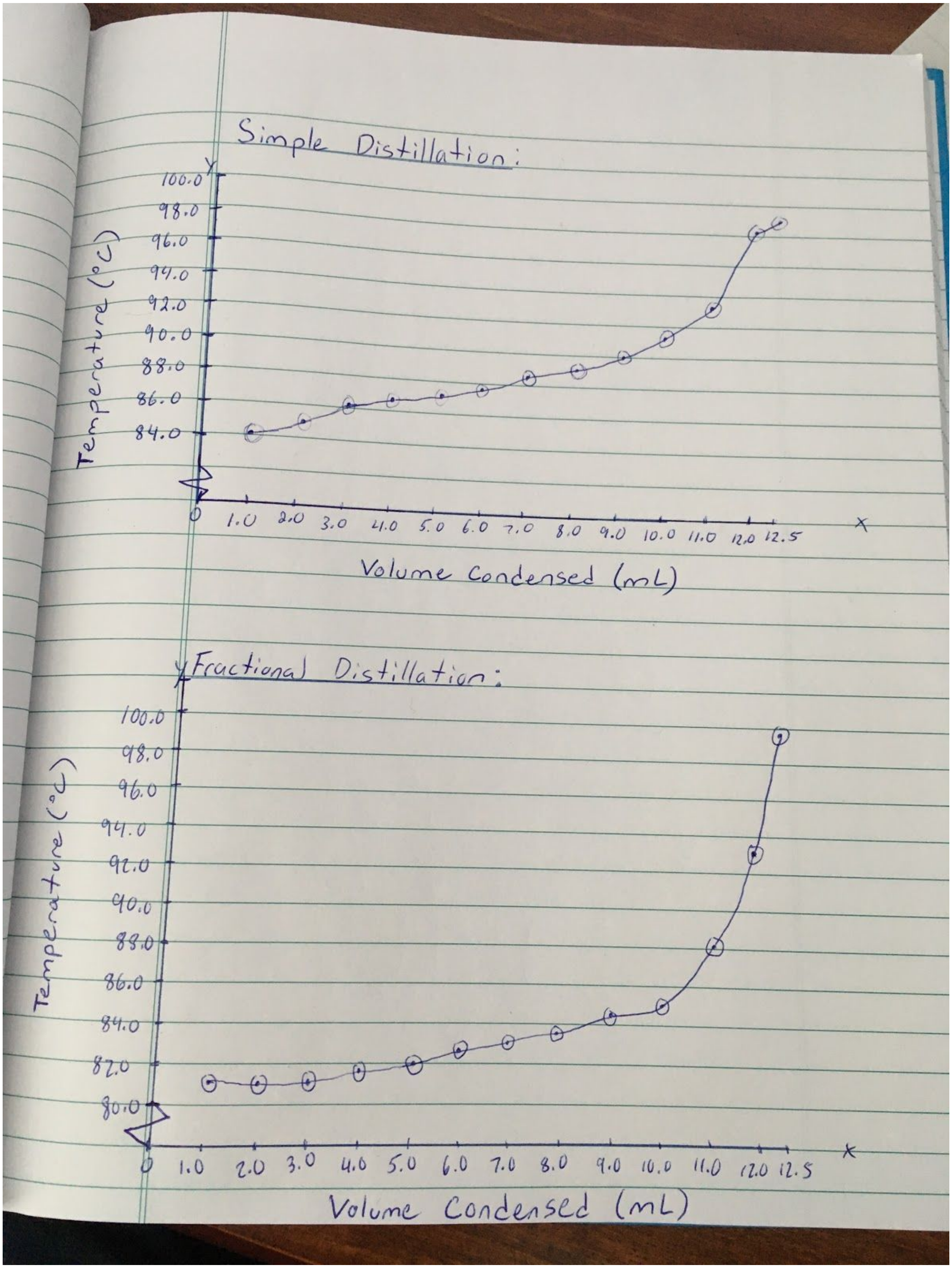
1.0	84.1
2.0	85.0
3.0	86.2
4.0	86.7
5.0	87.0
6.0	87.6
7.0	88.3
8.0	88.9
9.0	90.0
10.0	91.3
11.0	93.4
12.0	98.1
12.5	98.7

- **Fractional Distillation**

Volume Condensed (mL)	**Temperature (°C)**
1.0	81.1

2.0	81.1
3.0	81.2
4.0	81.7
5.0	82.0
6.0	82.6
7.0	82.9
8.0	83.5
9.0	84.6
10.0	85.2
11.0	88.1
12.0	93.0
12.5	99.5

Graphs:



Simple Distillation:
Temperature (°C)
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
12.5
Volume Condensed (mL)
Fractional Distillation:
Temperature (°C)
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
82.0
80.0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
12.5
Volume Condensed (mL)

Discussion:

- During the experiment, we were only told to collect 12.5 mL of solution in the graduated cylinder, and I was not able to obtain additional data from my TA, therefore I have only graphed up to volumes of 12.5 mL.
- Even though I only collected 12.5 mL of solution, it is still evident that the fractional distillation heats up very fast at around 10 mL. This is most likely the moment when 1-butanol began to condense as well.
- Comparing the two graphs, the simple distillation temperature grows rather uniformly in comparison to the fractional distillation. This most likely tells us that 2-propanol was not purely distilled in the simple distillation.
- Setting up both apparatus' was quite difficult because we needed to clamp all the necessary pieces of equipment. After setting up the apparatus and turning the heat on, all we needed to do was note the temperature after every mL that condensed. That portion of the experiment was not difficult.
- If we had collected data beyond 12.5 mL, our graphs would level off horizontally. Aside from this miscommunication, we the first ⅔ of my graphs and the sample graphs displayed in the procedure look very similar. Therefore, I can conclude that this experiment was a success in demonstrating that the fractional distillation is a much better form of distillation because it will separate two compounds rather distinctly, even if their boiling points have a small difference between them.
- One source of error could have been setting the heat too low or high. This could have altered the speed at which 2-propanol was being distilled, and therefore altered the speed at which 1-butanol was being distilled. If the heat was too high, the graph would have been compressed in width, and stretched in vertical length. If the heat was too low, the graph would have been stretched in width, and compressed in vertical length.
- Another source of error could have been setting the speed of the magnetic stirrer too high. If it was too high, the two compounds would separate much faster, and 2-propanol would distill very fast, and then some time would pass in order for the temperature to rise, and then 1-butanol would distill. The graph would most likely be almost horizontal until about 10.0 mL, and then shoot up very fast when the temperature is high enough for 1-butanol to distill.

Questions:

1. You must have liquid flowing back through the fractionating column because it must be kept at a cool temperature in order for the components to separate. This is because the vapor that is heated from the distillation flask must lower its temperature to then condense and turn into a liquid phase again.
2. It is important to maintain a uniform temperature gradient in a fractionating column because if heat escapes, the solution will not vaporize fully, and some portions of the compound may not be able to reach the condenser to then be collected in the final graduated cylinder.
3. The vapour pressure of benzene at 81 ^{o}C is about 791 mmHg.
4. At higher elevations, where the atmospheric pressure is lower, the boiling point is also lower. The boiling point and atmospheric pressure are directly proportional to each other, however, the boiling point will only increase up to the critical point, where the gas and liquid properties become identical.
5. Water must enter the bottom of the condenser because it must fill the entire condenser. A full condenser will maximize the transfer of heat for condensation. If you place the tubes so water enters from the top of the condenser, the water will drain from the bottom, and it will never completely fill up.
6. Using Raoult's Law, I have calculated the pressure of the mixture to be 300 mmHg. $P_{total} = (P_A)(N_A) + (P_B)(N_B)$ = (350 mmHG)(0.75) + (150 mmHg)(0.25) = **300 mmHg.**

Conclusion:

In conclusion, aside from only having data up to 12.5 mL of condensed solution, we were able to infer that our graphs resemble what was expected. Observing the fractional distillation graph of a sudden rise in temperature at about 10 mL in comparison to the simple distillation graph where the temperature rose rather consistently, we were able to determine that fractional distillation separates 2-propanol and 1-butanol much more distinctly than simple distillation.

Yuchen Dou
2018.01.23

~~Note~~ Fractional Distillation:

mL	temp (°C)
1.0	81.1
2.0	81.1
3.0	81.2
4.0	81.7
5.0	82.0
6.0	82.6
7.0	82.9
8.0	83.5
9.0	84.6
10.0	85.2
11.0	~~[illegible]~~ 88.1
12.0	93.0
12.5	99.5

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Simple Distillation:

mL poured	temperature (°C)
1.0	84.1
2.0	85.0
3.0	86.2
4.0	86.7
5.0	87.0
6.0	87.6
7.0	88.3
8.0	88.9
9.0	90.0
10.0	91.3
11.0	93.4
12.0	98.1
12.5	98.7