# Lab 3: Fractional Distillation of Alcohol from Wine[[1]](#footnote-1)

## Background

Chemistry can be used either to analyze a substance or to prepare a substance. This lab is an example of **analytical chemistry**: you will determine the level of alcohol in a bottle of wine. Analytical chemistry is either qualitative or quantitative. **Qualitative** chemistry describes a substance’s composition or properties; results of qualitative chemistry are descriptive. **Quantitative** chemistry determines the amounts or levels of molecule(s) in a sample; it counts something.

**Wine** is made when natural or added yeast ferment a fruit, typically grapes. The byproduct from this fermentation reaction is the “active” ingredient in wine, alcohol, specifically, ethanol or ethyl alcohol, abbreviated as EtOH. Wine is a complex mixture of organic compounds, but the most abundant are water, ethanol and sugar. Wine usually contains between 7 – 15% alcohol. In this experiment, you will be conducting **quantitative** analyzing of wine to determine the levelof alcohol in wine and compare it to the percentage of alcohol printed on the label.

**Technique**

You will use **distillation** to separate the ethanol from the wine. Distillation separates molecules based on significant differences in their boiling points. The boiling point of ethanol is 78 °C while the boiling point of water is 100 °C, so when wine is heated, ethanol will become a gas long before water provided the temperature stays above 78 but below 100 °C. As shown in **Figure 1**, a sample of wine is placed in a round-bottomed distillation flask that rests in an electronic heating mantle. Once the temperature reaches 78 °C, gaseous ethanol, called the distillate, rises up from the distillation flask into the **distillation head** attached above it. Increasing gas pressure pushes the vapor into a **water-cooled condenser**, whose lower temperature causes the vapor to condense into a liquid. The isolated liquid ethanol drips out of the condenser and is collected in a second, **collecting, flask**. Distillers use this same process to increase the alcohol content of ‘hard’ liquors. Using distillation, wine is turned into brandy (wine fortified with more alcohol) and vodka, whiskey, bourbon and other liquors are distilled from fermented mashes.

In order to keep the boiling wine from “bumping” or boiling over and pushing up into the distillation head, boiling chips are placed in the wine. Boiling chips are small, porous stones of calcium carbonate or silicon carbide that allow gases to come out of solution as small bubbles that don’t disturb the surface of the liquid in the flask.

Ethanol content will be quantitated as a volumetric **percentage** of the wine.

 Percent ethanol = mL ethanol recovered x 100

 mL wine sample



**Figure 1:** The distillation apparatus we’ll be using in this lab exercise.

**Notes on safety & waste disposal:**

* Absolutely **NO** substances found in a chemistry lab should be ingested, wine included!
* Ethanol is flammable so no open flames are allowed in this lab.
* NEVER plug the heating mantle directly into an outlet because it will overheat and pose a fire hazard. Instead, plug it into the Variac controller to safely regulate heating.
* Avoid getting ethanol on your skin.
* Boiling chips may be disposed of in the thrash after this lab.
* In this lab, all solutions may be poured down the drain for disposal.

**Materials**

* wine with a known alcohol content
* distillation glassware: round bottom flask, distillation head, water-cooled condenser
* hoses to connect the condenser to the water supply
* heating mantle
* thermometer
* ring-stands and clamps
* 10- and 100-mL graduated cylinders
* boiling chips

## Procedure:

1. Set up the heating mantle and Variac power source near an outlet and near the back of the bench. Plug the heating mantle into the Variac, and the Variac into the outlet.
2. Set up two ring-stands with clamps. One will steady the distillation head and the other will hold the condenser.
3. Use a graduated cylinder to collect 50.0 mL of wine. Record the volume and mass of the sample.
4. Carefully and completely transfer the wine to the round-bottomed distillation flask and add 2 – 3 boiling stones.
5. Secure the distillation head to the top of the distillation flask with a green Keck™ clip.
6. Clamp the head to the ring-stand so that the flask rests in the heating mantle.
7. Insert the thermometer into the top of the distillation head so that the thermometer bulb sits at the junction of the head and the connection to the condenser.
8. Attach inlet and outlet hoses to the condenser’s nipples. Be sure that the hoses will reach the faucet and sink once the condenser is in place.
9. Carefully fit the condenser onto the distillation head, securing it with a green Keck™ clip.
10. Clamp the condenser’s to the second ring-stand to support the glassware and maintain it’s connection to the distilling head.
11. Attach the lower (inlet) hose to the cold-water faucet and place the upper (outlet) hose into the sink.
12. Turn on the cold water slowly until the condenser’s outer tube is filled and water is flowing freely through. Don't worry about air bubbles at the top of the condenser.
13. Place a small graduated cylinder below the bottom of the condenser to collect the ethanol distillate. Resting the cylinder in ice will keep the collected ethanol in liquid form.
14. Turn the Variac dial up to begin heating the wine. Start with a setting of ‘6’ and watch the thermometer as you gently increase the heat. Remember, if the vapor temperature exceeds 78 °C ethanol is likely to be contaminated with other compounds! Slow heating is the key to success!
15. Record the time at which the first drops of ethanol are produced. Record the volume of ethanol every five minutes.
16. Do your best to keep the temperature below 95 °C. Distillation of ethanol is complete when distillate is no longer produced below 95 °C.
17. Record the total volume of ethanol collected, and the total time.
18. Turn off the heat and allow the glassware to cool enough for handling.
19. Pour what remains of the wine down the sink and throw the boiling chips in the trash.
20. Rinse distillation glassware in alcohol.
21. Do two more distillations using fresh boiling chips each time.
22. Calculate your results as the wine’s % ethanol. Then take the mean and standard deviation of this value.

##

## Cleanup:

Rinse all the glassware you used, and replace the distillation glassware on your lab bench. All beakers and graduated cylinders should be cleaned, dried and replaced in the community lab cabinets.

##

**Points to consider in your lab discussion section:**

* Did the experiment run smoothly? What would you have done differently if it did not?
* Can you explain the distillation process?
* Since both water and ethanol are clear/colorless liquids, how do you know if the ethanol or water was distilling?
* Does the data from the first trial compare well to the data from the second two trials?
* Are there certain trials that you believe may be more accurate than others? Why?
* How does the percent by volume of alcohol in wine compare to the label’s claim?
1. This lab was modified from “Determining the % Alcohol in Wine” from the Indiana University Dept. of Chemistry. [↑](#footnote-ref-1)