Tropospheric Ozone Testing Lab

In this lab, you will prepare and use chemically reactive paper to measure the concentration of ground-level (tropospheric) ozone. The ozone test paper used in this lab was first developed by Christian Friedrich Schoenbein in the early 1800s and is therefore called Schoenbein paper. Schoenbein paper is made by coating filter paper with a mixture of potassium iodide, corn starch and water. Schoenbein paper is hung in the air, out of direct sunlight, for eight hours which will allow a chemical reaction to take place (see below). If there is ozone in the air, the ozone will oxidize the potassium iodide (KI) on the Schoenbein paper to produce iodine. The iodine reacts with the corn starch to produce a purple color. The shade of purple on the paper correlates with the concentration of ozone present in the air.

$$2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$$

$$I_2 + \text{corn starch} \rightarrow \text{blue/purple color}$$

Experimental Question: How much tropospheric ozone is present in Ashland?

Materials:

Distilled Water
250-mL beaker
Corn starch
Electronic balance and weighing paper
Hot Plate
Stirring Rod/Magnetic stirrer
Potassium Iodide (KI)
Filter Paper
Paper plate or printer paper
Small paintbrush (or popsicle sticks)
Scissors
Ziploc bags
Spray bottle
Clothespins or paper clip hangers

Procedure for creating ozone test strips:

1. Place 100 mL of distilled water in a 250-mL beaker. Stir in approximately 5 g of corn starch.

2. Place the beaker on a hot plate. Heat the mixture over medium heat, while stirring carefully and constantly, until it becomes a translucent, thick gel-like substance. This will take at least a few minutes… be patient!

3. Remove the beaker from the hot plate with a hot mit. Stir approximately 1 g of potassium iodide (KI) into the mixture. Then let the solution cool to a paste.

5. Lay a piece of filter paper on a paper plate or printer paper. Use a small paint brush to brush the paste on the filter paper. Be sure to cover the paper completely and uniformly. Turn the paper over and cover the other side completely.

6. Dry the Schoenbein paper in a drying oven, at a low temperature. Fast drying can be accomplished in a microwave at low power for 30-60 seconds. But do NOT dry the Schoenbein paper in direct sunlight. It may not be exposed to direct sunlight at any point.

7. Use soap to wash hands and fingernails thoroughly. Potassium iodide is not toxic but can cause some mild skin irritations.

8. When the test strips are dry, cut the paper into strips one inch wide. They are now ready for immediate testing (procedure continued below). If not being hung in a test site right away, place the strips in an airtight Ziploc bag and keep them out of direct sunlight. The KI is sensitive to moisture and light.

Testing Procedure

1. **Determining test site locations:**
You and your partner, as well as the class as a whole, should come up with a variety of locations to test. Indoor and outdoor locations can be chosen, but you should test at least one outdoor area. Indoor sites you might chose could be the gym, cafeteria, teacher copying room, your laundry room, garage, etc.
Since we know that automobile emissions are a major source of nitrogen oxides and VOCs which contribute to ozone accumulation, an outdoor area that is near as much car traffic as possible would be the best outdoor location. Since we know that sunlight is required it would be best to have the test strips hanging during at least some of the daytime hours. But the key is that the ozone test strip may not be exposed to any direct sunlight. Let's be as creative as possible with selecting a variety of spots in Ashland!

2. If strips have been stored, spray a strip of test paper with distilled water. Hang it freely, out of direct sunlight at the test site for about eight hours.

3. Wash your hands thoroughly after handling the test strip containing KI.

4. Use internet weather sites (www.weather.com, www.weather.gov) to determine the relative humidity at the test site (via zip code). Round it to the nearest 10% and record the humidity in your data table.

5. After the test strip has been exposed to the air for eight hours, remove the strip and place it in an airtight Ziploc bag out of direct sunlight until you are ready to measure the results (continued below).

6. **Determine the ozone concentration of the air at the test site as follows:**
Spray or dip the strip in distilled water. Then compare the color of the strip with the Schoenbein Color Scale provided below and determine the Schoenbein Number. You will need to use a color copy of this scale provided in class or see this uploaded lab on our website for the color version of below. If the color of the paper is not uniform, use the color in the area with the most pronounced change to determine the value.

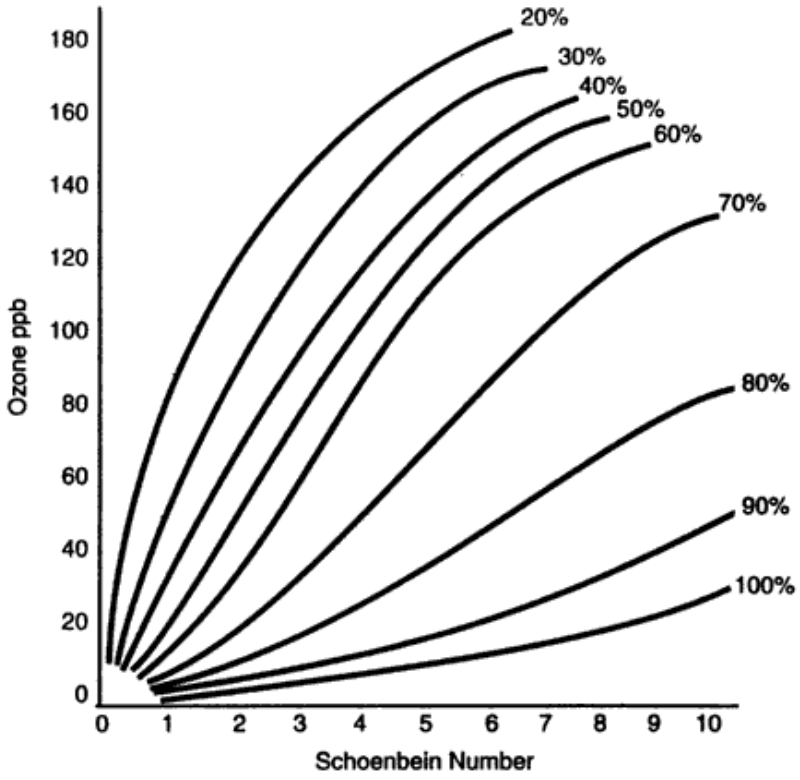
7. Use to the Relative Humidity Schoenbein Number Chart below to find the ozone concentration in the test site air. Find your test strip Schoenbein Number on the x axis. Draw a line upward from the Schoenbein Number until it intersects the curve that represents the humidity you determined was at the test site. Draw a line from the intersection to the y axis and the corresponding ozone concentration.

8. Record the data in your data table. The EPA Air Quality Standard for ozone is 0.075 ppm or 75 ppb over an eight-hour period.

Schoenbein Color Scale

Schoenbein Color Scale	
0 - 3	Little to no change
4 - 6	Lavender hue
7 - 10	Blue or Purple

Relative Humidity Schoenbein Number Chart



Data Table: *We may do this through Google Docs in order to get everyone's data easily.*

Location description	Humidity (%)	Schoenbein #	Ozone (ppb)

Analysis Questions:

1. Compare your Schoenbein paper ozone readings to other students' locations. Discuss whether results were similar or different to yours and why.

2. Describe how weather conditions could have affected your outdoor ozone results.

3. Go to Google and search for: Mass DEP MassAir Online
   Click on the first link (http://public.dep.state.ma.us/MassAir/Pages/MapCurrent.aspx?&ht=1&hi=101) which will show a map of Massachusetts with colored icons at air testing sites that are generally tested daily. (See the top of the map for the last updated time). The color of the icons refers to the current Air Quality Index (AQI) rating. See the key for the color-coded AQI system on the map and scroll down to see more AQI info below the map.
   Zoom in and click on the icons nearest to Ashland. The bubbles that come up list the criteria pollutants recently measured. (You can also click the tab "Table View" at the top of the map).

   Here are the National Ambient Air Quality Standards, as set by the EPA in the Clean Air Act:
   Ozone (O_3): 0.075 ppm (eight hour exposure)
   Carbon monoxide (CO): 9 ppm (eight hour exposure)
   Nitrogen dioxide (NO_2): 0.053 ppm (annual average)
   Sulfur dioxide (SO_2): 0.03 ppm (annual average)
   Fine particles (PM2.5): 15 $\mu g/m^3$ (annual average)

   Find the information for the chart below at sites as close to Ashland as possible. You may need to click on a couple locations to find levels for the five air pollutants listed below. You may create a table like is below or list the information:

	Current level & unit	Location	Below/above EPA standard
Ozone (O_3)			
Nitrogen dioxide (NO_2)			
Sulfur dioxide (SO_2)			
Carbon monoxide (CO)			
Fine particulates: PM2.5			
AQI			n/a

4. How does the ozone you detected compare to the closest ozone reading? *(1 ppm = 1000 ppb)*

5. Looking at the Relative Humidity Schoenbein Number Chart, what Schoenbein number would show ozone at the EPA Air Quality Standard limit at 20% humidity? At 50% humidity? At 70% humidity?

Lab Report

We will complete a full lab report for this lab. Remember to use the lab rubric and guideline sheet (posted on Ms. Graham's website too). The Word document of this lab is also found on the website as well (now under Labs: Semester Two).
Note: Your data table should include everyone's data. Your conclusion should be based on everyone's data. Make sure to mention the range in ozone concentrations that we recorded at all sites and some discussion of why we likely saw higher/lower concentrations at the different locations.