Today, we will:
- Discuss the classification of air pollutants (CAPS, HAPS, NAAQS, etc.)
- View a short Powerpoint presentation about visible emissions [Note: thumbnails of my Powerpoint slides are provided on the course website.]
- Do some practice/review problems

**Classification of Air Pollutants:** Know these terms and their definitions!
The Environmental Protection Agency (EPA) classifies air pollutants as follows:

**One way that EPA classifies air pollutants:**

**Primary Air Pollutant:** A pollutant emitted *directly* from the source.

**Secondary Air Pollutant:** A pollutant *not* emitted *directly* from the source, but *formed in the atmosphere by chemical reactions of primary sources.*

The EPA is concerned with both primary and secondary air pollutants.
A second way that EPA classifies air pollutants:

**Natural Air Pollutant**: A pollutant emitted by processes *not associated with human activity*.

**Anthropogenic Air Pollutant**: A pollutant emitted by processes *associated with human activity*.

A third way that EPA classifies air pollutants:

**Criteria Air Pollutants (CAPs)**: Pollutants for which *National Ambient Air Quality Standards (NAAQS) exist*. There are 7 *original* CAPs. Memorize these!

- CO (carbon monoxide)
- SO₂ (sulfur dioxide)
- NO₂ (nitrogen dioxide)
- O₃ (ozone)
- PM₂.₅ (Particulate Matter < 2.5 microns diameter) Also called **fine particles**
- PM₁₀ (Particulate Matter < 10 microns diameter) Also called **coarse particles**
- Pb (lead)

**Hazardous Air Pollutants (HAPs)**: Pollutants on EPA’s list of chemicals that are considered to be *hazardous to your health*. EPA defines HAPs as “**pollutants that cause of may cause cancer or other serious health effects**.”
Clean Air Act of 1970:

Legislation that established **NAAQS** (National Ambient Air Quality Standards) for each of the **CAPs** (Criteria Air Pollutants).

**NAAQS Standards:**

**Primary standards:** Standards to *protect the health of “sensitive” populations.*

**Secondary standards:** Standards to *protect the public welfare.*

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NAAQS Table

The **Clean Air Act**, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. **Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. **Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The EPA has set National Ambient Air Quality Standards for six principal pollutants, which are called *"criteria" air pollutants*. Periodically, the standards are reviewed and may be revised. The current standards are listed below. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m³).
<table>
<thead>
<tr>
<th>Pollutant [links to historical tables of NAAQS reviews]</th>
<th>Primary/Secondary</th>
<th>Averaging Time</th>
<th>Level</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon Monoxide (CO)</strong></td>
<td>primary</td>
<td>8 hours</td>
<td>9 ppm</td>
<td>Not to be exceeded more than once per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hour</td>
<td>35 ppm</td>
<td></td>
</tr>
<tr>
<td><strong>Lead (Pb)</strong></td>
<td>primary and secondary</td>
<td>Rolling 3 month average</td>
<td>0.15 μg/m^3(^{(1)})</td>
<td>Not to be exceeded</td>
</tr>
<tr>
<td><strong>Nitrogen Dioxide (NO(_2))</strong></td>
<td>primary</td>
<td>1 hour</td>
<td>100 ppb</td>
<td>98th percentile of 1-hour daily maximum concentrations, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>primary and secondary</td>
<td>1 year</td>
<td>53 ppb(^{(2)})</td>
<td>Annual Mean</td>
</tr>
<tr>
<td><strong>Ozone (O(_3))</strong></td>
<td>primary and secondary</td>
<td>8 hours</td>
<td>0.070 ppm(^{(3)})</td>
<td>Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years</td>
</tr>
<tr>
<td><strong>Particle Pollution (PM)</strong></td>
<td>primary</td>
<td>1 year</td>
<td>12.0 μg/m^3</td>
<td>annual mean, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>secondary</td>
<td>1 year</td>
<td>15.0 μg/m^3</td>
<td>annual mean, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>primary and secondary</td>
<td>24 hours</td>
<td>35 μg/m^3</td>
<td>98th percentile, averaged over 3 years</td>
</tr>
<tr>
<td><strong>PM(_{10})</strong></td>
<td>primary and secondary</td>
<td>24 hours</td>
<td>150 μg/m^3</td>
<td>Not to be exceeded more than once per year on average over 3 years</td>
</tr>
<tr>
<td><strong>Sulfur Dioxide (SO(_2))</strong></td>
<td>primary</td>
<td>1 hour</td>
<td>75 ppb(^{(4)})</td>
<td>99th percentile of 1-hour daily maximum concentrations, averaged over 3 years</td>
</tr>
<tr>
<td></td>
<td>secondary</td>
<td>3 hours</td>
<td>0.5 ppm</td>
<td>Not to be exceeded more than once per year</td>
</tr>
</tbody>
</table>
The air in the USA is getting cleaner each year in spite of growth of GDP, vehicle miles traveled, and population. Here is an interesting comparison plot from EPA (downloaded 24 January 2020 from https://www.epa.gov/air-trends/air-quality-national-summary)

See Powerpoint Slides Thumbnails - Introduction to visible emissions, acid rain (on main ME 433 website)
Practice questions to help you prepare for the exams:

1. A container has 40.2 g of water vapor. How many mols of water vapor are in the sample? [Note: You will be able to look up $M_{\text{water}} = 18.02$ g/mol.]

2. The mol fraction of CO ($M_{\text{CO}} = 28.0$ g/mol) in a container of sampled polluted air is 50 PPM. The overall pressure of the gas mixture in the container is 100 kPa. Calculate the mass fraction of the CO in the container in units of mg/kg.

3. A container of sampled air contains mostly air, but also some carbon monoxide pollution ($M_{\text{carbon monoxide}} = 28.0$ g/mol). The total volume of the container is 0.456 m$^3$ and the partial volume of CO in the container is 2.43E-4 m$^3$. The container is at SATP conditions. Calculate the mass of CO in the container in grams.

4. The mass concentration of ammonia ($M_{\text{ammonia}} = 17.04$ g/mol) is 1.11 g/m$^3$. When the pressure is 97.3 kPa and the temperature is 573.15 K, calculate the mol fraction of the ammonia vapor in PPM.