Sources of CO₂ Experiment Exhibition

** Due: Monday, 03/26/2018 **

This exhibition includes:
- Abstract **Extra Credit**
- Part 1: Experimental Design
- Part 2: Data Table and Graph
- Part 3: Data Analysis, Conclusion, Sources of Error, Discussion

Abstract **Extra Credit**
An abstract is a short paragraph that summarizes the experiment for someone with no background information.

HOW TO WRITE AN ABSTRACT: Answer the following questions individually and in full sentences using only the most important details.

- **Objective and Motivation**: What was the goal or purpose of the experiment?
- **Procedure**: Describe the procedure in only 1-2 sentence(s)
- **Results**: Report only the important observations and findings.
- **Conclusions**: What claim can you make based on the data?

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Background on Car Exhaust

There are more than 600 million cars driving roads all over the world. While pollution reduction laws have reduced harmful emissions over the past 20 years, the numbers of cars and trucks on the road and the miles they are driven have doubled in the same period. Vehicles are now driven two trillion miles each year in the United States.¹

The exhaust system of an automobile is designed to carry away the gases created when the fuel and oxygen in the air are burned in the combustion chamber of the engine. The exhaust from a combustion engine consists mostly of water vapor (H₂O), and carbon dioxide (CO₂).

Some exhaust contains toxic gases such as carbon monoxide (CO), nitrogen oxides (NOₓ), Ozone (O₃), and particulate matter in high enough concentrations to contribute to respiratory problems in humans and wreak havoc in Earth’s fragile atmospheric envelope of gasses of which most life depends.

Carbon monoxide is a colorless and odorless asphyxiant that combines with the hemoglobin in the bloodstream causing a decrease the amount of oxygen delivered to the tissues. This can lead to dizziness, loss of consciousness and in some cases—death. In the United States, 75% of CO emissions come from motor vehicles such as cars, trucks, boats, and construction equipment. The current Occupational Safety and Health Administration (OSHA) permissible exposure limit for carbon monoxide is 50 parts per million (ppm).²

Approximately half of the NOₓ released in car exhaust is released in the initial minutes after start up, when the catalytic converter is not in full operation. Nitrogen oxides are created when the heat in the engine forces nitrogen in the air to combine with oxygen. This NOₓ plays a significant role in the formation of acid rain and it plays a key role in upper atmosphere and in ground-level ozone formation. Reducing the NOₓ released in the initial start-up of the car could successfully cut the environmental burden by as much as 25 percent.³

In a study of the effects of car exhaust on children, researchers discovered that a high rate of road traffic was correlated to increased respiratory symptoms in children.⁴

Policies and regulations that require automobile manufacturers to reduce harmful emissions have led to innovations like Catalytic Converters (most cars have been equipped since the mid-70’s.)

In chemistry, a catalyst is a substance that causes or accelerates a chemical reaction without itself being affected. Catalysts participate in the reactions, but are neither reactants nor products of the reaction they catalyze. In the human body, enzymes are naturally occurring catalysts responsible for many essential biochemical reactions. In your car, the Catalytic Converter strips the Oxygen molecule from the NOₓ and holds onto the nitrogen and releases the O₂. Then it oxidizes the carbon monoxide and turns it into carbon DIOXIDE.⁵

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2 US Dept of Labor, Occupational Health and Safety Guideline for Carbon Monoxide (Retrieved Feb 20011)
3 Clean school bus initiative through EPA. (Retrieved Feb 2011) http://www.epa.gov/otaq/schoolbus/index.htm
Part 1

Directions: Answer the following questions based on your experiment.

Testable Question: _____________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Hypothesis: _________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
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Answer the following questions:

1. What was your **independent variable** in this experiment? (Define what it is and what you used for your experiment).
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   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

2. What was your **dependent variable** in this experiment? (Define what it is and what you used for your experiment).
   __________________________________________________________________________
   __________________________________________________________________________
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3. List all of the **constants** in this experiment.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
4. Why are **constants** necessary in an experiment?

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5. What was your **control** in this experiment? Why did we have TWO?

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6. Why do we need a **control** in an experiment?

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## Part 2

**Directions:** Fill in the data table below with your data from the experiment.

### Sources of CO₂ Qualitative Data

<table>
<thead>
<tr>
<th>Gas Sample</th>
<th>Color of BTB Solution (write the color and the number from the color scale)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Control</td>
<td>color: __________ # on scale: ______</td>
<td>circumference: ________________</td>
</tr>
<tr>
<td>Positive Control</td>
<td>color: __________ # on scale: ______</td>
<td>circumference: ________________</td>
</tr>
<tr>
<td>Air</td>
<td>color: __________ # on scale: ______</td>
<td>circumference: ________________</td>
</tr>
<tr>
<td>Car Exhaust</td>
<td>color: __________ # on scale: ______</td>
<td>circumference: ________________</td>
</tr>
<tr>
<td>Human Breath</td>
<td>color: __________ # on scale: ______</td>
<td>circumference: ________________</td>
</tr>
</tbody>
</table>

Use the data set below to calculate the mean for each sample.

### Sources of CO₂ Quantitative Data

<table>
<thead>
<tr>
<th>Gas Sample</th>
<th>Concentration of CO₂ (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>Positive Control</td>
<td>99,600</td>
</tr>
<tr>
<td>Air</td>
<td>967</td>
</tr>
<tr>
<td>Car Exhaust</td>
<td>52,800</td>
</tr>
<tr>
<td>Human Breath</td>
<td>18,834</td>
</tr>
</tbody>
</table>

PPM = parts per million
Directions: Use the data set you were given to make a bar graph showing the concentration of CO₂ in the gas samples. Plot the RAW DATA (as points) and the MEAN (as a bar). Make sure you label the axis and include a title.
Part 3

Directions: Answer the following questions.

Data Analysis:
The data (NUMBERS!) is the evidence that supports your conclusion or claim. Use as much quantitative data as possible. Do NOT interpret the results. Do not make any conclusions or inferences about why yet (this happens in the conclusion).

For EACH set up:
- Describe if the raw data is consistent or not.
- Calculate and identify the range in the data.
- Identify specific outliers!
- AVOID NAKED NUMBERS!

Data Analysis Vocabulary:

<table>
<thead>
<tr>
<th>consistent/repeatable</th>
<th>outlier</th>
<th>mean</th>
<th>spread</th>
<th>range</th>
<th>representative</th>
</tr>
</thead>
</table>

Positive control

Air

Car Exhaust

Human Breath
Conclusion:
Answer your testable question using BOTH mean and raw data as evidence. (Refer to the “Sources of Error and Writing Conclusions Review Packet”).

Sources of Error and Limitations:

1. Describe at least three sources of error in your experiment.
   - What was the effect of these sources of error on your results?
   - Were these errors human errors or experimental errors? Explain.
Discussion:

2. How does this experiment relate to our current unit? Provide two pieces of evidence from “Background on Car Exhaust” on page 2.

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3. What is the real world significance of the results? How do these results affect you and/or the student body at Eastside? Given the data, what next steps should we take?

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