Name: Date: Class:

Pre-Activity Problem Set Answer Key

Answer the following questions.

1. What is the chemical equation for complete combustion?

   Fuel + O_2 → CO_2 + H_2O

2. What pollutants might result if incomplete combustion is occurring?

   CO, VOCs, particulate matter (and still CO_2 and H_2O)

3. Is NOx formed from the fuel itself? If not, where does it come from? Yes or (No)

   Thermal NOx is formed form the N_2 already present in the air (air ~ 21% O_2 and 79% N_2).

4. Which fuel has a higher energy content? Gasoline or (Diesel)

Answer the following questions using the example data in the table below.

Independent Variables			Dependent Variables (concentrations observed at tailpipe)		
Fuel	**Formula**	**Combustion temperature (°C)**	**CO_2 (ppm)**	**VOC (ppm)**	**NOx (ppm)**
Case 1: Gasoline	C_8H_{18}	1500	3000	30	20
Case 2: Diesel	$C_{12}H_{23}$	1900	3000	50	40
Case 3: Ethanol	C_2H_5OH	1500	4000	10	20

5. What is similar about the chemical formulas for all of the fuel sources?

   All contain carbon and hydrogen.

6. What is different about ethanol, and why might that difference result in lower VOCs?

   Ethanol has oxygen in the fuel, which facilitates more complete combustion and therefore fewer VOCs.

7. Which requires more oxygen to reach complete combustion? Gasoline or diesel? And, why?

   Diesel, because it contains more carbon, or a higher carbon/hydrogen ratio; you need two oxygens for each carbon to get to CO_2.

8. Which fuel type results in the most NOx and why?

   Diesel, because of the higher combustion temperature.

Name: **Date:** **Class:**

9. In the following table, circle the **A** or **B** that best completes the row. Then explain your rationale.

Claim	Evidence	Reason
Vehicle 1 produces more total pollutants than vehicle 2.	We observe higher CO_2 *and* higher VOCs in the vehicle 1 data.	**A. Vehicle 1 has an older engine.** **B. Vehicle 1 has a larger engine.**
Vehicle 2 exhibits more complete combustion than vehicle 1.	**A. We observe more VOCs from vehicle 1 than vehicle 2.** **B. We observe more VOCs from vehicle 2 than vehicle 1.**	Vehicle 2 is newer and operating more efficiently, therefore it is displaying more complete combustion.
A. The combustion in vehicle 1 is hotter. **B. The combustion in vehicle 2 is hotter.**	We observe more NOx from vehicle 1 than vehicle 2.	Vehicle 1 has a diesel engine.

Explanations

Row 1: A larger engine uses more fuel, which results in more overall emissions, while an older engine may run poorly and may exhibit more incomplete combustion, but not necessarily more emissions.

Row 2: More incomplete combustion leads to more VOCs.

Row 3: Diesel engines run at a hotter temperature and typically produce more NOx.

Name: **Date:** **Class:**

CHALLENGE QUESTION

10. To the air-fuel ratio plot on the right, add a line for CO_2.

    Explanation of CO_2 line placement (the red line). Moving from left to right:

    1. To begin with, CO_2 will be at a minimum.
    2. It will increase as more O_2 is added.
    3. It will plateau as CO reaches a minimum (and achieves more complete combustion).
    4. As the VOCs increase, the CO_2 decreases slightly.