3.6: Conservation of Mass

Combustion is the process of burning something in the presence of oxygen. In Figure 3.6.1, the first image shows a pyrotechnic display at a P!nk concert caused by burning a combustible fuel. The second image shows roasting marshmallows over hot coals and ashes that remain from burning wood. In each case, it seems as if the material (fuel) being burned simply disappears. Sure, heat is obtained and it is obvious that ashes remain after the wood burns, but what really happens? Does the matter simply disappear?

In each case, oxygen gas (obtained from the air) is used to drive the combustion by undergoing a chemical reaction with the fuel as it burns. The combustion leads to the formation of carbon dioxide gas and water vapor. These gases float off into the air. In the case of burning wood, ashes remain as well. Had we been able to measure the combined mass of the fuel and oxygen before they were burned and compared it to the combined mass of the carbon dioxide, water vapor, and any other product (such as the remaining ashes in the fire pit) after they were burned, we would find out that the total mass of the matter before their combustion is equal to the total mass of the matter after combustion.

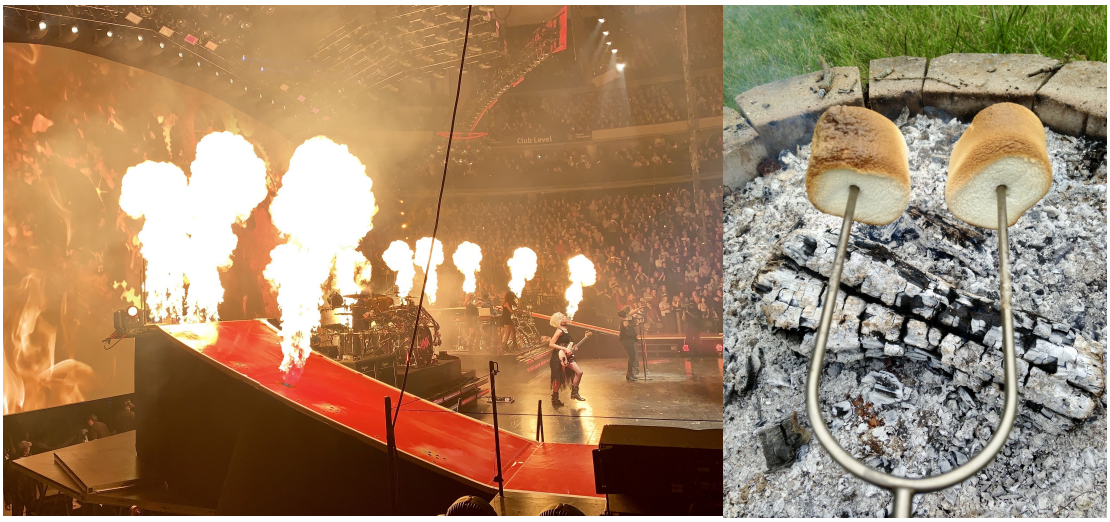

Figure 3.6.1: Flames in a pyrotechnic display at a P!nk concert. Roasting marshmallows over a backyard fire pit. (Lance S. Lund)

Law of Conservation of Mass

The law of conservation of mass was described in 1789 by a French chemist, Antoine Lavoisier. The **law of conservation of mass** states that matter can neither be created nor destroyed in a chemical reaction. For example, when wood burns, the mass of the soot, ashes, and gases equals the original mass of the wood and the oxygen when it first reacted. So the mass of the product equals the mass of the reactant. Reactants are the substances present before a change occurs while product(s) are the substances formed as the result of a chemical reaction (Video 3.6.1). Matter and its corresponding mass may not be able to be created or destroyed, but it may change forms to other substances like liquids, gases, and solids.

Video 3.6.1: A demonstration showing the conservation of mass in action.

If you witness a 300 kg tree burn to the ground, there are only ashes left after burning and all of them together weigh 10 kg. It may make you wonder where the other 290 kg went. The missing 290 kg was released into the atmosphere as smoke, so the only thing left that you can see is the 10 kg of ash. If you know the law of conservation of mass, then you know that the other 290 kg has to go somewhere because the products have to equal the mass of the tree before it burnt down.

✅ Example 3.6.1

If heating 10.0 grams of calcium carbonate ($CaCO_3$) produces 4.4 g of carbon dioxide (CO_2) and 5.6 g of calcium oxide (CaO), show that these observations are in agreement with the law of conservation of mass.

Solution

$$\text{Mass of the reactants} = \text{Mass of the products}$$
$$10.0\,\text{g of } CaCO_3 = 4.4\,\text{g of } CO_2 + 5.6\,\text{g of CaO}$$
$$10.0\,\text{g of reactant} = 10.0\,\text{g of products}$$

Because the mass of the reactant is equal to the mass of the products, the observations are in agreement with the law of conservation of mass.

✏️ Exercise 3.6.1

Potassium hydroxide (KOH) readily reacts with carbon dioxide, CO_2, to produce potassium carbonate, K_2CO_3, and water, H_2O. How many grams of potassium carbonate are produced if 224.4 g of KOH reacts with 88.0 g of CO_2? The reaction also produces 36.0 g of water.

Answer

276.4 g of potassium carbonate

The law is also applicable to physical changes. For example, if you have an ice cube that melts into a liquid and you heat that liquid up, it becomes a gas. It will appear to have disappeared but is still there. The mass of the ice cube, the mass of the liquid, and the mass of the gas will all be the same.

Summary

- Burning and other changes in matter do not destroy matter.
- The mass of matter is always the same before and after the changes occur.
- The law of conservation of mass states that matter cannot be created or destroyed.