ChemQuest 32

Information: Mole Ratios in Equations

- Propane is burned in many rural homes for heat in the winter. Below is the balanced equation for the combustion of propane (C_3H_8). $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
- For each molecule of propane that is burned, there needs to be five molecules of oxygen present.
- Likewise, if there were a dozen molecules of propane, five dozen molecules of oxygen would be required.
- Similarly, for each **mole** of propane, five **moles** of oxygen are needed.
- Also, for each mole of propane burned three moles of carbon dioxide and 4 moles of water are produced.
- **The numbers of moles of each substance in a chemical equation are related by the ratio of the coefficients of each substance.**

Critical Thinking Questions

Note: For questions 1-6, refer to the balanced equation for the combustion of propane.

1. a) How many moles of water are produced when 1.45 moles of propane are combusted?
   b) How many molecules of water is this? (Remember each mole has 6.02×10^{23} molecules.)

2. If 2.35 moles of CO_2 are produced in a reaction, how many moles of H_2O would be produced?

3. Why is this statement false: "If 10 grams of propane burn, you need 50 grams of oxygen."

4. a) If 27.3 moles of carbon dioxide are produced during the combustion of a certain amount of propane, how many moles of propane were combusted?

   b) How many grams of propane was this?

5. If you have 410 grams of propane and want to know how many grams of oxygen are required to burn it, you can follow these steps…
   a) Find the number of moles of propane that you have. Convert grams to moles!

   b) The moles of propane are related to the moles of oxygen by the ratio of coefficients in the balanced chemical equation. Find the number of moles of oxygen you need given the molesof propane from part a.

   c) Find the grams of oxygen from the moles of oxygen. Convert the moles of oxygen (answer to part b) to grams of oxygen (O_2)! (Note: use the molar mass for O_2, not just O. You should get approximately 1490 g of oxygen.)

6. Verify that this statement is correct: If 315 grams of propane combusts, then approximately 515 grams of water are produced.

7. Consider the decomposition of ammonia: $2\ NH_3 \rightarrow 3\ H_2 + N_2$. If you start with 425 g of NH_3, how many grams of H_2 and N_2 can be produced?

ChemQuest 33

Information: Limiting Reactant

- Again consider the combustion of propane: $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$. If you had 10 moles of propane to burn, you would need 50 moles of oxygen according to the ratio in the balanced equation.
- If you only had 20 moles of oxygen you could not combust all 10 moles of propane.
- The reaction has been **limited** by the amount of oxygen you have—you don't have enough oxygen to burn all of the propane. In this case, oxygen is called the "limiting reactant" because it limits how much propane can react.
- Notice that the limiting reactant isn't always the substance that is present in the fewest number of moles.
- In this example, propane (C_3H_8) is the "excess reactant" because after the reaction there will be some of it left over. It is important to remember that everything in a chemical equation is related by mole ratios.
- If you only know the mass (grams) of the substances, you need to convert to moles.

Critical Thinking Questions

8. a) In the above discussion, it was evident that 20 moles of oxygen was not sufficient to combust 10 moles of propane. How many moles of the propane can be combusted with 20 moles of oxygen?

b) How many moles of carbon dioxide will be produced? (Base the answer to this question on the number of moles of propane that actually get combusted—which is your answer to part a.)

c) Verify that if 12.5 moles of propane and 63.2 moles of oxygen were present, then propane is the "limiting reactant" and oxygen is the excess reactant.

9. Consider the following chemical reaction: $3\ MgCl_2 + 2\ Na_3PO_4 \rightarrow 6\ NaCl + Mg_3(PO_4)_2$.
Assume that 0.75 mol of $MgCl_2$ and 0.65 mol of Na_3PO_4 are placed in a reaction vessel.

a) Verify that Na_3PO_4 is the excess reactant and $MgCl_2$ is the limiting reactant.

b) How many moles of the excess reactant are left over after the reaction stops?

c) How many moles of NaCl will be produced in this reaction? (Remember—you must base this answer on how many moles of the limiting reactant that reacted.)

10. Consider the double replacement reaction between calcium sulfate ($CaSO_4$) and sodium iodide (NaI). If 34.7 g of calcium sulfate and 58.3 g of sodium iodide are placed in a reaction vessel, how many grams of each product are produced? (Hint: Do this problem in the steps outlined below.)
a) Write the balanced chemical equation for the reaction.

b) Find the limiting reactant. First, convert 34.7g and 58.3g from grams to moles using the molar masses from the periodic table. Next, compare the number of moles of each reactant.
(Ask yourself: Do I have enough NaI to use up all of the $CaSO_4$? Do I have enough $CaSO_4$ to use up all of the NaI? Whichever one will get used up is the limiting reactant.)

c) Use the number of moles of the limiting reactant to calculate the number of moles of each product produced using the coefficients from the balanced chemical equation in part a.

d) In part c you found the moles of each product produced. Now convert moles to grams using the molar mass from the periodic table. You have now answered the question.