Connected Chemistry

Reactions Unit

Student Appendix A: Limiting and Excess Reactants

Example

1. 10 grams of aluminum burns with 10 grams of oxygen. How much aluminum oxide is formed?

   Calculating the limiting reactant and the amount of product that is formed based on the limiting reactant.

$$\mathbf{Al\ (s) + O_2\ (g) \rightarrow Al_2O_3\ (s)}$$

2. Balance the equation.

   If the equation is not balanced, the math will be wrong later.

$$\mathbf{4\ Al\ (s) + 3\ O_2\ (g) \rightarrow 2\ Al_2O_3\ (s)}$$

3. Convert grams of reactants from the problem into moles.

Molar mass of Al = 26.98 g/mol of Al

Molar mass of O_2 = 15.99 g/mol × 2 atoms of oxygen = 31.99 g/mol of O_2

10 g Al × (1 mol Al/ 26.98 g Al) = 0.37 mol Al

10 g O_2 × (1 mol O_2/ 31.99 g O_2) = 0.31 mol O_2

4. Remember that the coefficient on the substance indicates how many moles are present of that substance in the reaction. Determine how many moles of product each of the reactants can produce. To do this, multiply moles of each of the reactants by the ratio of product to reactant. This allows for the cancellation of units, which is moles of reactant, leaving moles of product. This is where a correctly balanced equation is important.

0.37 mol Al × (2 mol of Al_2O_3 / 4 mol of Al) = 0.185 mol Al_2O_3

0.31 mol O_2 × (2 mol of Al_2O_3 / 3 mol of O_2) = 0.207 mol of Al_2O_3

5. Identify the limiting reactant by comparing the values of product from the previous step. The reactant that yields less product limits the reaction.

0.185 moles of Al_2O_3 is less than 0.207 moles of Al_2O_3. Aluminum is the limiting reactant because 10 grams of Al produces less Al_2O_3 than 10 grams of O_2.

6. Convert moles to grams to determine how much product is produced based on the amount of limiting reactant available.

Molar mass of Al_2O_3 = (2 atoms of Al × 26.98 g/mol) + (3 atoms of O_2 × 15.99 g/mol) = 101.96 g/mol

0.185 mol Al_2O_3 × 101.96 g/mol = 31.61 g Al_2O_3

7. Since one of the reactants was available in a limited amount (aluminum in our example), there may be some of the other reactant left over. To find the amount of excess reactant, determine how much of the non-limiting reactant (oxygen) actually did react with the limiting reactant (aluminum).

10 g Al × (1 mol Al/ 26.98 g Al) × (3 mol O_2/ 4 mol Al) × (31.99 g O_2/ 1 mol O_2) =

8.89 g O_2 reacted

10 g O_2 (initial) - 8.89 g O_2 (reacted) = 1.11 g excess O_2