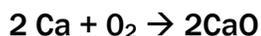


Calculations involving reactions

- An equation is a statement which expresses info about reactants and products
- You need specific ingredients and specific amounts of ingredients (like a recipe)
 - Ex. Doubling the ingredients doubles the results
- **YOU GET OUT WHAT YOU PUT IN!**
- Ex: Combination of Calcium and Oxygen



- This is the balanced equation. It also holds true for different amounts as well. For example:



- As you can see, these substances combine in a very specific ratio (in this case 2:1:2)
- This ratio is called the mole ratio (or molar ratio)
 - 2 moles of Ca combine with 1 mole of O₂ to produce 2 moles of CaO
- But, we do not need exactly 2 moles of Ca and 1 mole of oxygen gas. If we have 1 mole of Ca, we only need 0.5 moles of O₂.
- Ex:
 - 3 mol Ca + 1.5 mol O₂ → 3 mol CaO
 - 0.5 mol Ca + 0.25 mol O₂ → 0.5 mol CaO
 - 0.1 mol Ca + 0.05 mol O₂ → 0.1 mol CaO
- We can use this knowledge to determine how much reactant we need.
 - Ex: We want to produce 0.3 mol of CaO. How much Ca and O₂ is required?
 - Answer:
 - We know the molar ratio is: 2 : 1 : 2
 - We know how much product (CaO) we want: 0.3 mol
 - We also know the amount of Ca must equal the amount of CaO because the molar ratio of these two things is 2:2 (Therefore we need 0.3 mol of Ca)
 - Finally, we know the amount of O₂ must be ½ of the amount of Ca, because the molar ratio is 2:1 (Therefore we need 0.15 mol of O₂)
- Likewise, we can also predict the amount of product.
 - Ex: How much CaO will be produced by 0.175 mol of O₂?
 - Answer:
 - Molar ratio: 2 : 1 : 2
 - CaO is double the amount of O₂, therefore: 2 (0.175 mol) = 0.35 mol of CaO
- The study of chemical reactions is called **Stoichiometry**.
 - This involves measuring and calculating the amount of elements and compounds involved in a chemical change.
- The molar ratio gives us the building blocks of matter. This is the **KEY** to all Stoichiometry calculations.

Limiting Reactant

- There are times when there is too much of one substance and not enough of another in order for all the matter available to react.
- The species that does not have enough to completely react all of the other matter is called the limiting reactant.
- The other species is called in excess.
- Example: If we have 5 atoms of Ca and 1 molecule of O₂, what will react?
- Answer:
 - Molar ratio: 2 : 1 : 2
 - Here we can use 2 atoms of Ca for every 1 molecule of O₂. Since we only have 1 molecule of O₂ available, there will be 3 leftover atoms of Ca.
 - Here O₂ is the limiting reactant. Ca is in excess.

Steps to Calculating reactants and products

- 1) Write a balanced equation
- 2) Determine the molar ratio of reactants and products
- 3) Determine what is given and what is required
- 4) Convert moles to grams and grams to moles depending upon what is given
- 5) Calculate the unknown using the molar ratio

Example: Calculate the number of moles of sodium oxide that will be produced when 5.0 moles of sodium react with oxygen. (For this question we only use steps 1-3)

Mole-Mass Calculations

- In these types of questions, moles are given and mass is required
- Use the above steps to solve these problems
 - **REMEMBER: the only way we can compare amounts using the balanced formula is to convert everything into moles.**

Example: How many moles of Na are needed to react with oxygen to produce 800.0 g of Na₂O?

Mass-Mass Calculations

- In these types of questions we are given mass and asked to find mass.
- These types of questions are similar to mole-mass questions.
- Once again, remember that the only way we can compare between two different species is to get a balanced equation and compare the amount of MOLES for each. (The molar ratio only works when we use moles of the substances involved.)

Example: Calculate the mass of lithium oxide produced when 100.0 g of lithium reacts with an excess of oxygen.

Actual Yield and % Yield

- In lab conditions, not every single atom reacts (like it should in theory)
- A reactant is added in excess which will cause the limiting reactant to be completely converted into product (all of it is used up).
- The theoretical yield is the yield of the limiting reactant if ALL of it is converted into product. (This does not often happen in reality.)
 - Experimental conditions produce a yield less than the theoretical yield, which is called the actual yield
- To determine the percent yield we use this formula: $\% \text{ Yield} = \frac{\text{actual yield}}{\text{Theoretical yield}} \times 100$
- % Yield gives us the efficiency of the reaction (high % is efficient)
- When using solutions, volume and concentrations must be converted into moles to determine yield