

Answer on Question #43243 - Chemistry - Other

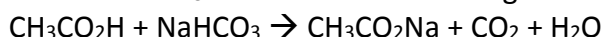
Question:

The group decided to use 250.0 ml of vinegar of 24.0 grams of baking soda. What is the limiting reactant?

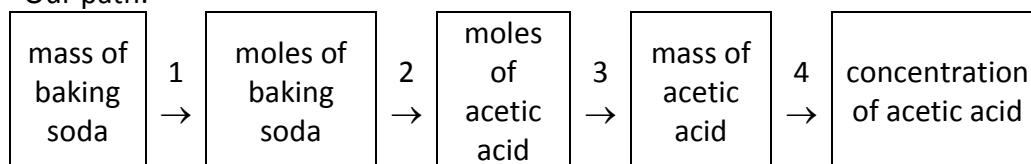
Solution:

To solve this problem, it is necessary to know the exact concentration of acetic acid in vinegar, because manufacturers produce many types of vinegar with different concentrations. Most often, concentration of acetic acid in vinegar ranges from 4% to 8%. In this case, it is possible to calculate the concentration of vinegar making the assumption that 250 ml of vinegar reacts completely with 24 grams of baking soda.

Acetic acid $\text{CH}_3\text{CO}_2\text{H}$ reacts with baking soda NaHCO_3 according to the equation:



Our path:



1. Molar mass of NaHCO_3 is $23+1+12+16\times 3=84$ g/mol
 $1 \text{ mol NaHCO}_3/84 \text{ g NaHCO}_3$
 $24 \text{ g NaHCO}_3 \times 1 \text{ mol NaHCO}_3/84 \text{ g NaHCO}_3 = 0,29 \text{ mol NaHCO}_3$
2. From the balanced equation we see that 1 mole of NaHCO_3 reacts with 1 mole of $\text{CH}_3\text{CO}_2\text{H}$, then 0,29 moles of NaHCO_3 react with 0,29 moles of $\text{CH}_3\text{CO}_2\text{H}$
3. Mass of 1 mole of $\text{CH}_3\text{CO}_2\text{H}$ is $12+ 1\times 3+12+16\times 2=60$ g/mol
 $0,29 \text{ mol CH}_3\text{CO}_2\text{H} \times 60 \text{ g CH}_3\text{CO}_2\text{H} / 1 \text{ mol CH}_3\text{CO}_2\text{H} = 17,4 \text{ g CH}_3\text{CO}_2\text{H}$
4. In this step density of vinegar is needed.

Data from textbook:

Concentration of acetic acid in vinegar, %	Density of vinegar, g/ml
4	1,004
5	1,0055
6	1,007
7	1,0084
8	1,010

making the assumption that concentration of acetic acid is 7%, we can calculate the mass of acetic acid in 250 ml of vinegar:

Mass of vinegar=Volume \times density= $250 \text{ ml} \times 1,0084 \text{ g/ml}=252 \text{ g}$,

Mass of acetic acid = mass of vinegar \times concentration / 100%= $252 \text{ g} \times 7\% / 100\%= 17,6 \text{ g}$.

17,6 g $\text{CH}_3\text{CO}_2\text{H}$ is very close to 17,4 g $\text{CH}_3\text{CO}_2\text{H}$. It means, that 250 ml of vinegar with concentration of acetic acid equals to 7% reacts completely with 24 g of baking soda.

Answer: If concentration of Acetic acid in vinegar is more than 7%, the limiting reactant is baking soda. If concentration of Acetic acid in vinegar is less than 7%, the limiting reactant is vinegar.