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 CH_3CO_2H reacts with baking soda $NaHCO_3$ according to the equation:
$CH_3CO_2H + NaHCO_3 \rightarrow CH_3CO_2Na + CO_2 + H_2O$
Our path:

mass of baking soda	1 →	moles of baking soda	2 →	moles of acetic acid	3 →	mass of acetic acid	4 →	concentration of acetic acid

1. Molar mass of $NaHCO_3$ is $23+1+12+16\times3=84$ g/mol
   1 mol $NaHCO_3$/84 g $NaHCO_3$
   24 ~~g $NaHCO_3$~~ $\times$1 mol $NaHCO_3$/84 ~~g $NaHCO_3$~~ =0,29 mol $NaHCO_3$
2. From the balanced equation we see that 1 mole of $NaHCO_3$ reacts with 1 mole of CH_3CO_2H, then 0,29 moles of $NaHCO_3$ react with 0,29 moles of CH_3CO_2H
3. Mass of 1 mole of CH_3CO_2H is $12+ 1\times3+12+16\times2=60$ g/mol
   0,29 ~~mol CH_3CO_2H~~ $\times$60 g CH_3CO_2H /1 ~~mol CH_3CO_2H~~= 17,4 g CH_3CO_2H
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 ~~ml~~ $\times$1,0084 g/~~ml~~=252 g,
Mass of acetic acid = mass of vinegar $\times$ concentration / 100%= 252 g $\times$ 7% / 100%= 17,6 g.
17,6 g CH_3CO_2H is very close to 17,4 g CH_3CO_2H. It is 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.