Answer on Question #58182 – Chemistry – Organic Chemistry

Task:

Assume that 3.0 g of aniline and 4.5 mL of acetic anhydride (density ρ = 1.08 g mL-1) are used in the preparation of acetanilide.

1) What is the limiting reagent? Justify your answer.
2) What is the theoretical yield in grams of acetanilide?
3) What is the % yield if 3.30 g of acetanilide are obtained?

Solution:

We write the reaction of interaction the aniline with acetic anhydride to form acetanilide:

aniline   acetic anhydride   acetanilide   acetic acid
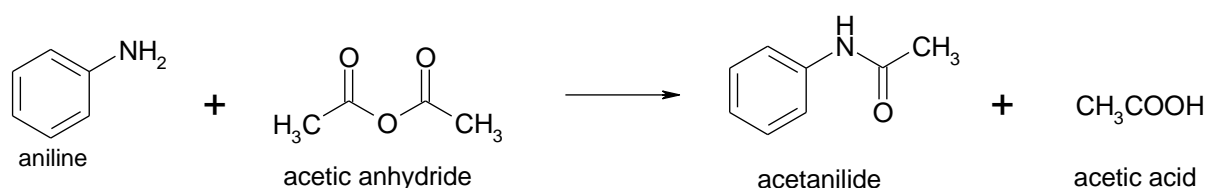
We find the molar mass of aniline and acetic anhydride:

$$M\left(aniline\right) = M\left(C_6H_5NH_2\right) = 12\times6+1\times7+14\times1 = 93(\frac{g}{mol});$$

$$M(acetic\ anhydride) = M(C_4H_6O_3) = 12\times4+1\times6+16\times3 = 102(\frac{g}{mol}).$$

Convert each substance to moles:

$$n\left(aniline\right) = \frac{m(C_6H_5NH_2)}{M\left(C_6H_5NH_2\right)} = \frac{3g}{93\frac{g}{mol}} = 0.0322mol;$$

$$n(C_4H_6O_3) = \frac{m(C_4H_6O_3)}{M(C_4H_6O_3)} = \frac{\rho(C_4H_6O_3)\times V(C_4H_6O_3)}{M(C_4H_6O_3)} = \frac{1.08\frac{g}{ml}\times4.5ml}{102\frac{g}{mol}} = 0.0476mol$$

1) To find the limiting reagent, take the moles of each substance and divide it by the coefficient of the balanced equation. The substance that has the smallest answer is the limiting reagent.

Determine the limiting reagent:
For aniline: 0.0322 / 1 = 0.0322
For acetic anhydride: 0.0467 / 1 = 0.0476.

There is enough acetic anhydride to produce 0.0467 mol acetanilide, but only enough aniline to produce 0.0322 mol acetanilide. This means that the amount of acetanilide actually produced is limited by the aniline, which is therefore the limiting reagent.

Answer:

Limiting reagent is aniline.

2) Aniline and acetanilide stand in a one-to-one molar relationship, so 0.0322 mol of aniline produces 0.0322 mol of acetanilide. The amount of acetic anhydride does not play a role, since it is in excess.
Then,

$$n\left(aniline\right) = n(aceta \, n \, ilide) = 0.0322 mol.$$

We find the molar mass of acetanilide:

$$M(aceta \, n \, ilide) = M(C_8H_9NO) = 12 \times 8 + 1 \times 9 + 14 \times 1 + 16 \times 1 = 135 (g/mol).$$

We find the theoretical yield in grams of acetanilide:

$$m(aceta \, n \, ilide) = n(C_8H_9NO) \times M(C_8H_9NO) = 0.0322 mol \times 135 \, g/mol = 4.347 g \approx 4.35 g.$$

Answer:

The theoretical yield of acetanilide is 4.35g.

3) What is the % yield if 3.30 g of acetanilide are obtained?
Theoretical yield: 4.35g.
Actual yield: 3.30g.

Percent yield (%Yield):

$$\% \, Yield = \frac{Actual \, Yield \, (mass \, or \, moles)}{Theoretical \, Yield \, (mass \, or \, moles)} \times 100\% \, .$$

Then,

$$Percent \, Yield = \frac{Actual \, Yield}{Theoretical \, Yield} \times 100\% = \frac{3.30 g}{4.35 g} \times 100\% = 75.86\%.$$

Answer:

Percent yield of acetanilide is 75.86%.