Example 2

$CH_3COOH + HOCH_2CH_2CH(CH_3)_2 \longrightarrow CH_3COOCH_2CH_2CH(CH_3)_2 + H_2O$

acetic acid — Isopentyl alcohol — Isopentyl acetate

85.0 g acetic acid react with 45.0 g of isopentyl alcohol to produce 46.51 g of isopentyl acetate. What are the theoretical and percentage yields?

Solution

It is a limiting-reactant problem since amounts of the two reactants are given.

$n_{acid} = \left(\frac{85}{60}\right)$ mols $= 1.416$ mols

$n_{alcohol} = \left(\frac{45}{88}\right)$ mols $= 0.511$ mols

M_r (acetic acid) $= 60\ g\,mol^{-1}$

M_r (alcohol) $= 88\ g\,mol^{-1}$

M_r (acetate) $= 130\ g\,mol^{-1}$

ratio of the reactants :

$$r_{theoretical} = \frac{n_{acid}}{n_{alcohol}} = \frac{1}{1} = 1.00$$ ← from the balanced equation.

$$r_{experimental} = \frac{n_{acid}}{n_{alcohol}} = \left(\frac{1.416}{0.511}\right) = 2.77$$

$r_{experimental}$ (2.77) $>$ $r_{theoretical}$ (1.00)

This is due to the numerator is large (acid is in excess), whereas the denominator is small (alcohol is the limiting reagent)

$n_{acetate} \equiv n_{alcohol} = 0.511$ mols

$\therefore m_{acetate} = (0.511 \times 130\ g\,mol^{-1}) = 66.43\ g$

$\therefore$ theoretical yield $= 66.43\ g$

$$\% \text{ yield} = \frac{\text{acetate produced}}{\text{acetate calculated}} \times 100 = \left(\frac{46.51}{66.43} \times 100\right)$$

$= 70.0$ (Ans)

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