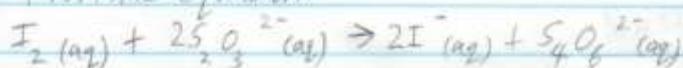


Cider 1 - Average Titration Volume = 30.76 mL

$$\begin{aligned}\textcircled{1} \quad n_{\text{Cr}_2\text{O}_7^{2-}} &= CV \\ &= 0.04 \text{ M} \times 0.02 \text{ L} \\ &= 0.0008 \text{ mol}\end{aligned}$$

$$\begin{aligned}\textcircled{2} \quad n_{\text{S}_2\text{O}_3^{2-}} &= CV \\ &= 0.1 \text{ M} \times 0.03076 \text{ L} \\ &= 0.003076 \text{ mol}\end{aligned}$$

$\textcircled{3}$ From the equation:



$$\frac{n_{\text{want}}}{n_{\text{given}}} = \frac{n_{\text{I}_2}}{n_{\text{S}_2\text{O}_3^{2-}}} = \frac{1}{2} = \frac{x}{0.003076 \text{ mol}}$$

$$\begin{aligned}\therefore x &= \frac{1}{2} \times 0.003076 \text{ mol} \\ x &= 0.001538 \text{ mol}\end{aligned}$$

$\textcircled{4}$ From the equation:



$$\frac{n_{\text{want}}}{n_{\text{given}}} = \frac{n_{\text{Cr}_2\text{O}_7^{2-}}}{n_{\text{I}_2}} = \frac{1}{3} = \frac{x}{0.001538 \text{ mol}}$$

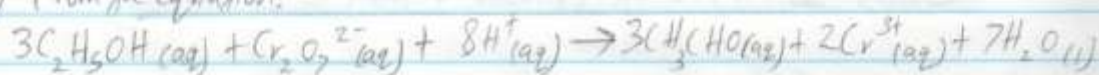
$$\begin{aligned}\therefore x &= \frac{1}{3} \times 0.001538 \text{ mol} \\ x &= 0.00051266 \text{ mol}\end{aligned}$$

$$\textcircled{5} \quad \text{Excess } \text{Cr}_2\text{O}_7^{2-} = 0.00051266 \text{ mol}$$

$$\text{Original } \text{Cr}_2\text{O}_7^{2-} = 0.0008 \text{ mol}$$

$$\begin{aligned}\therefore \text{Cr}_2\text{O}_7^{2-} \text{ that reacted with } \text{C}_2\text{H}_5\text{OH} &= 0.0008 \text{ mol} - 0.00051266 \text{ mol} \\ &= 0.0002873 \text{ mol}\end{aligned}$$

⑥ From the equation:



$$\frac{n_{want}}{n_{given}} = \frac{n_{C_2H_5OH}}{n_{Cr_2O_7^{2-}}} = \frac{3}{1} = \frac{x}{0.0002873 \text{ mol}}$$

$$\therefore x = 0.0002873 \text{ mol} \times 3$$

$$x = 0.000862 \text{ mol}$$

$$\therefore [C_2H_5OH] = \frac{n}{V}$$

$$= \frac{0.000862 \text{ mol}}{0.02 \text{ L}}$$

$$= 0.0431 \text{ M} \quad (\text{concentration of } 20 \text{ mL ethanol solution sample from } 250 \text{ mL volumetric flask})$$

$$\textcircled{7} \quad [C_2H_5OH](250 \text{ mL}) = [C_2H_5OH](20 \text{ mL})$$

$$\therefore [C_2H_5OH](250 \text{ mL}) = 0.0431 \text{ M}$$

$$\begin{aligned} \therefore n_{C_2H_5OH}(250 \text{ mL}) &= CV \\ &= 0.0431 \text{ M} \times 0.25 \text{ L} \\ &= 0.010775 \text{ mol} \end{aligned}$$

$$\textcircled{8} \quad M_{C_2H_5OH} = 46 \text{ g mol}^{-1}$$

$$n_{C_2H_5OH} = \frac{m}{M}$$

$$\therefore m = nM$$

$$m = 0.010775 \text{ mol} \times 46 \text{ g mol}^{-1}$$

$$m = 0.49565 \text{ g}$$

$$\textcircled{9} \quad \rho = \frac{m}{V} \quad (\rho_{\text{ethanol}} = 0.785 \text{ g mL}^{-1})$$

$$\therefore 0.785 \text{ g mL}^{-1} = \frac{0.49565}{V}$$

$$\therefore \% \text{ ethanol} = \frac{0.6314 \text{ mL}}{5 \text{ mL}} \times 100$$

$$= 12.628\%$$

$$V = \frac{0.49565}{0.785 \text{ g mL}^{-1}}$$

$$V = 0.6314 \text{ mL} \leftarrow \text{volume of ethanol in original } 5 \text{ mL sample.}$$

Cider 2 - Average Titration Volume = 24.96 mL

$$\begin{aligned}\textcircled{1} \quad n_{\text{Cr}_2\text{O}_7^{2-}} &= CV \\ &= 0.04 \text{ M} \times 0.02 \text{ L} \\ &= 0.0008 \text{ mol}\end{aligned}$$

$$\begin{aligned}\textcircled{2} \quad n_{\text{S}_2\text{O}_3^{2-}} &= CV \\ &= 0.1 \text{ M} \times 0.02496 \text{ L} \\ &= 0.002496 \text{ mol}.\end{aligned}$$

$\textcircled{3}$ From the equation:

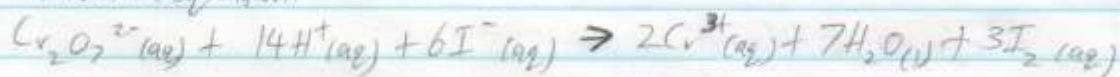


$$\frac{n_{\text{want}}}{n_{\text{given}}} = \frac{n_{\text{I}_2}}{n_{\text{S}_2\text{O}_3^{2-}}} = \frac{1}{2} = \frac{x}{0.002496 \text{ mol}}$$

$$\therefore x = \frac{1}{2} \times 0.002496 \text{ mol}$$

$$x = 0.001248 \text{ mol}$$

$\textcircled{4}$ From the equation:



$$\frac{n_{\text{want}}}{n_{\text{given}}} = \frac{n_{\text{Cr}_2\text{O}_7^{2-}}}{n_{\text{I}_2}} = \frac{1}{3} = \frac{x}{0.001248 \text{ mol}}$$

$$\therefore x = \frac{1}{3} \times 0.001248 \text{ mol}$$

$$x = 0.000416 \text{ mol}.$$

$$\textcircled{5} \quad \text{Excess } \text{Cr}_2\text{O}_7^{2-} = 0.000416 \text{ mol}$$

$$\text{Original } \text{Cr}_2\text{O}_7^{2-} = 0.0008 \text{ mol}$$

$$\begin{aligned}\therefore \text{Cr}_2\text{O}_7^{2-} \text{ that reacted with } \text{C}_2\text{H}_5\text{OH} &= 0.0008 \text{ mol} - 0.000416 \text{ mol} \\ &= 0.000384 \text{ mol}\end{aligned}$$

⑥ From the equation:

$$3\text{C}_2\text{H}_5\text{OH}(\text{aq}) + \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 8\text{H}^+(\text{aq}) \rightarrow 3\text{CH}_3\text{COOH}(\text{aq}) + 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$$

$$\frac{n_{\text{want}}}{n_{\text{given}}} = \frac{n_{\text{C}_2\text{H}_5\text{OH}}}{n_{\text{Cr}_2\text{O}_7^{2-}}} = \frac{3}{1} = \frac{x}{0.000384\text{mol}}$$

$$\therefore x = 3 \times 0.000384\text{mol}$$

$$x = 0.001152\text{mol}$$

$$\begin{aligned}\therefore [\text{C}_2\text{H}_5\text{OH}](20\text{mL}) &= \frac{n}{V} \\ &= \frac{0.001152\text{mol}}{0.02\text{L}} \\ &= 0.0576\text{M}\end{aligned}$$

$$\textcircled{7} [\text{C}_2\text{H}_5\text{OH}](250\text{mL}) = [\text{C}_2\text{H}_5\text{OH}](20\text{mL})$$

$$\therefore [\text{C}_2\text{H}_5\text{OH}](250\text{mL}) = 0.0576\text{M}$$

$$\begin{aligned}\therefore n_{\text{C}_2\text{H}_5\text{OH}}(250\text{mL}) &= CV \\ &= 0.0576\text{M} \times 0.25\text{L} \\ &= 0.0144\text{mol}\end{aligned}$$

$$\textcircled{8} M_{\text{C}_2\text{H}_5\text{OH}} = 46\text{g mol}^{-1}$$

$$n_{\text{C}_2\text{H}_5\text{OH}} = \frac{m}{M}$$

$$\therefore m = nM$$

$$m = 0.0144\text{mol} \times 46\text{g mol}^{-1}$$

$$m = 0.6624\text{g}$$

$$\textcircled{9} \rho = \frac{m}{V} \quad (\rho_{\text{ethanol}} = 0.785\text{g mL}^{-1})$$

$$\therefore 0.785\text{g mL}^{-1} = \frac{0.6624\text{g}}{V}$$

$$V = \frac{0.6624\text{g}}{0.785\text{g mL}^{-1}}$$

$$\therefore \% \text{ ethanol} = \frac{0.84382\text{ mL}}{5\text{mL}} \times 100$$

$$= 16.8764\%$$

$$V = 0.84382\text{ mL} \leftarrow \text{volume of ethanol in original 5mL sample.}$$