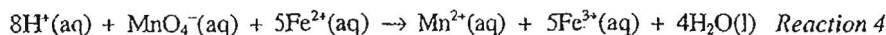


In the corresponding oxidation half-reaction, the Fe^{2+} ion is oxidized to Fe^{3+} :



Combining half-reactions 2 and 3 and balancing the number of electrons transferred gives the overall reaction equation:



The balanced equation shows that 5 moles of Fe^{2+} are required to react with 1 mole of MnO_4^{-} .

For this redox titration, the *equivalence point* occurs when the exact number of moles of Fe^{2+} ions has been added to react completely with all the MnO_4^{-} ions in solution. At this point:

$$\text{moles Fe}^{2+} = 5 \times (\text{moles MnO}_4^{-}) \quad \text{Equation 1}$$

If the volume and molarity of the Fe^{2+} solution are known, then:

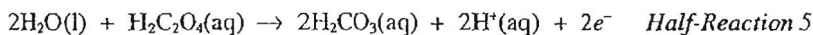
$$V_{\text{Fe}^{2+}} M_{\text{Fe}^{2+}} = 5 V_{\text{MnO}_4^{-}} M_{\text{MnO}_4^{-}} \quad \text{Equation 2}$$

Rearranging Equation 2 yields the equation for the concentration of the potassium permanganate solution.

$$M_{\text{MnO}_4^{-}} = \frac{(V_{\text{Fe}^{2+}})(M_{\text{Fe}^{2+}})}{5 (V_{\text{MnO}_4^{-}})}$$

The indicator for this titration is the MnO_4^{-} ion itself. The MnO_4^{-} ion is purple in solution. At the endpoint of the titration, the solution changes from light pink to colorless.

In Part 2, the concentration of an oxalic acid solution is determined by titration with the permanganate solution standardized in Part 1. In this case, the endpoint occurs when the pink color of the MnO_4^{-} ion persists. The half-reaction for the oxidation of oxalic acid is:



The oxidation state of carbon changes from (+3) in $\text{H}_2\text{C}_2\text{O}_4$ to (+4) in H_2CO_3 .

Experiment Overview

The purpose of this lab is to standardize a solution of potassium permanganate by redox titration with a standard solution of iron(II) ions. A solution of oxalic acid is then titrated with the permanganate solution to determine the exact concentration of oxalic acid.

Pre-Lab Questions

- Write the balanced net ionic equation for the reaction between MnO_4^{-} ions and $\text{H}_2\text{C}_2\text{O}_4$ in acid solution. $2\text{MnO}_4^{-} + 5\text{H}_2\text{C}_2\text{O}_4 + 6\text{H}^{+} = 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$
- How many moles of Fe^{2+} ions can be oxidized by 0.043 moles of MnO_4^{-} ions? $\text{Moles Fe}^{2+} = 5 \cdot 0.043 = 0.215 \text{ mol Fe}^{2+}$
- 1.630 g of iron ore is dissolved in an acidic solution. This solution is titrated to a pink endpoint with 27.15 mL of a 0.020 M KMnO_4 solution.
 - How many moles of MnO_4^{-} ions were consumed? $\text{MnO}_4^{-} = 0.020 \text{ M} \times 0.02715 \text{ L} = 0.000543$
 - How many moles of Fe^{2+} were in the iron ore sample? $\text{moles Fe}^{2+} = 5 \cdot 0.000543 = 0.00272$
 - What is the percent of iron in the iron ore sample? $\text{Mass Fe} = 0.00272 \text{ mol} \cdot 55.847 \text{ g/mol} = 0.152 \text{ g}$

$$\% \text{ Fe} = 0.152 + 100 / 1.630 = 9.33\% \text{ Fe}$$

Data Tables

Part 1

Molarity of Fe²⁺ 0.100 M

	Trial 1	Trial 2	Trial 3
Volume of Fe ²⁺ solution titrated	10 mL	10 mL	10 mL
Initial volume of MnO ₄ ⁻ solution	2.58 mL	4.69 mL	7.00 mL
Final volume of MnO ₄ ⁻ solution	4.69 mL	7.00 mL	9.1 mL
Volume of MnO ₄ ⁻ added	2.11 mL	2.31 mL	2.1 mL

Part 2

Molarity of MnO₄⁻ solution 0.00947 M

	Trial 1	Trial 2
Volume of H ₂ C ₂ O ₄ solution titrated	25 mL	25 mL
Initial volume of MnO ₄ ⁻ solution	9.1 mL	32.0 mL
Final volume of MnO ₄ ⁻ solution	32.0 mL	41.2 mL
Volume of MnO ₄ ⁻ added	22.9 mL	9.2 mL

Molarity of H₂C₂O₄ solution _____ M

Post-Lab Calculations

1. From the Part 1 standardization data, calculate the molarity of the MnO₄⁻ solution for each trial. Average the values and enter the average in the Part 2 Data Table.

$0.00947 M / 22.9 = 0.216$ moles of MnO₄⁻

2. From the Part 2 titration data, calculate the molarity of the H₂C₂O₄ solution for each trial. Average the values and enter the average in the Part 2 Data Table.

3. How many moles of Fe²⁺ ions and MnO₄⁻ ions were titrated in each Part 1 trial?

$0.100 M \cdot 10 = 1 \text{ mol Fe}^{2+} \text{ ions}$

$0.00947 M \cdot 2.11 = 0.0200 \text{ mol MnO}_4^-$

4. How many moles of oxalic acid, H₂C₂O₄, were titrated in each Part 2 trial?

$0.216 \text{ mol MnO}_4^- / 5 \text{ mol H}_2\text{C}_2\text{O}_4 / 2 \text{ mol MnO}_4^- = 0.54 \text{ mol H}_2\text{C}_2\text{O}_4$