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

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^- \qquad \textit{Half-Reaction 3}$$

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

$$8H^+(aq) + MnO_4^-(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l) \qquad \textit{Reaction 4}$$

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:

$$\text{moles } Fe^{2+} = 5 \times (\text{moles } MnO_4^-) \qquad \textit{Equation 1}$$

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

$$V_{Fe^{2+}} M_{Fe^{2+}} = 5\, V_{MnO_4^-} M_{MnO_4^-} \qquad \textit{Equation 2}$$

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

$$M_{MnO_4^-} = \frac{(V_{Fe^{2+}})(M_{Fe^{2+}})}{5\,(V_{MnO_4^-})}$$

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:

$$2H_2O(l) + H_2C_2O_4(aq) \rightarrow 2H_2CO_3(aq) + 2H^+(aq) + 2e^- \qquad \textit{Half-Reaction 5}$$

The oxidation state of carbon changes from (+3) in $H_2C_2O_4$ 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

1. Write the balanced net ionic equation for the reaction between MnO_4^- ions and $H_2C_2O_4$ in acid solution. $2MnO_4 + 5H_2C_2O_4 + 6H^+ = 2Mn^{2+} + 10CO_2 + 8H_2O$
2. How many moles of Fe^{2+} ions can be oxidized by 0.043 moles of MnO_4^- ions? Moles $Fe^{2+} = 5 \cdot 0.043 = 0.215$ mol Fe^{2+}
3. 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.
   a. How many moles of MnO_4^- ions were consumed? $MnO_4 = 0.020 \text{ M} \times 0.02715\text{L} = 0.000543$
   b. How many moles of Fe^{2+} were in the iron ore sample? moles $Fe^{2+} = 5 \times 0.000543 = 0.00272$
   c. What is the percent of iron in the iron ore sample? Mass $Fe = 0.00272 \text{ mol} \times 55.847 \text{ g/mol} = 0.152$ g

% Fe = 0.152 ÷ 1.630 = 9.33% Fe

Data Tables

Part 1

Molarity of Fe^{2+} .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	7.09 mL
Final volume of MnO_4^- solution	4.69 mL	7.09 mL	9.1 mL
Volume of MnO_4^- added	2.11 mL	2.31 mL	2.1 mL

Part 2

.00947 M

Molarity of MnO_4^- solution ~~1.00~~ M

	Trial 1	Trial 2
Volume of $H_2C_2O_4$ 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 $H_2C_2O_4$ solution _____ M

Post-Lab Calculations

1. From the Part 1 standardization data, calculate the molarity of the MnO_4^- solution for each trial. Average the values and enter the average in the Part 2 Data Table.

.00947M | 22.9 = 0.216 moles of MnO_4

2. From the Part 2 titration data, calculate the molarity of the $H_2C_2O_4$ solution for each trial. Average the values and enter the average in the Part 2 Data Table.

3. How many moles of Fe^{2+} ions and MnO_4^- ions were titrated in each Part 1 trial?

.100M • .10 = (1 mol Fe^{2+} ions) .00947 M • 2.11 = 0.200 mol MnO_4

4. How many moles of oxalic acid, $H_2C_2O_4$ were titrated in each Part 2 trial?

0.216 mol MnO_4 | 5 mol $H_2C_2O_4$ / 2 mol MnO_4 | = 0.54 mol $H_2C_2O_4$