



Oxidation and Reduction Set 22: Redox Titrations

1.



$$v = 29.0 \text{ mL} \quad v = 25.0 \text{ mL}$$

$$c = ? \quad c = 0.105 \text{ molL}^{-1}$$

$$\begin{aligned} n(\text{MnO}_4^-) &= 1/5 n(\text{Fe}^{2+}) &=& 1/5 (c \times v) \\ & &=& 1/5 (0.105 \times 0.0250) \\ & &=& 5.25 \times 10^{-4} \text{ mol} \\ c(\text{MnO}_4^-) &= n/v &=& \frac{5.25 \times 10^{-4}}{0.0290} \\ & &=& 0.0181 \text{ molL}^{-1} \\ & &=& \mathbf{1.81 \times 10^{-2} \text{ molL}^{-1}} \end{aligned}$$

2.

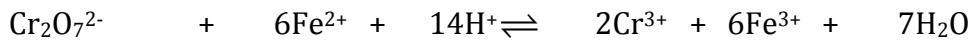


$$v = 31.2 \text{ mL} \quad v = 25.0 \text{ mL}$$

$$c = 0.0201 \text{ molL}^{-1} \quad c = ?$$

$$\begin{aligned} n(\text{H}_2\text{C}_2\text{O}_4) &= 5/2 n(\text{MnO}_4^-) &=& 5/2 (v \times v) \\ & &=& 5/2 (0.0201 \times 0.0312) = 0.0015678 \\ c(\text{H}_2\text{C}_2\text{O}_4) &= n/v &=& \frac{0.0015678}{0.0250} \\ & &=& 0.0627 \text{ molL}^{-1} = \mathbf{6.27 \times 10^{-2} \text{ molL}^{-1}} \end{aligned}$$

3.



$$c = 0.0214 \text{ molL}^{-1} \quad v = 20.0 \text{ mL}$$

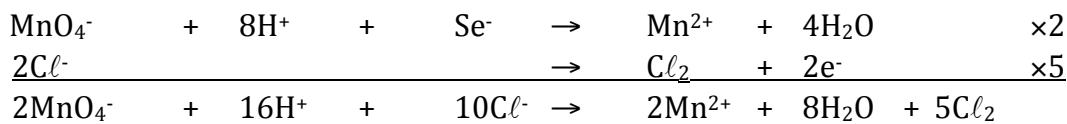
$$v = 20.5 \text{ mL} \quad c = ?$$

$$\begin{aligned} n(\text{Cr}_2\text{O}_7^{2-}) &= cV &=& 0.0214 \times 0.0205 = 4.387 \times 10^{-4} \text{ mol} \\ n(\text{Fe}^{2+}) &= 6 n(\text{Cr}_2\text{O}_7^{2-}) &=& 2.632 \times 10^{-4} \text{ mol} \\ c(\text{Fe}^{2+}) &= \frac{n}{V(L)} &=& \frac{2.632 \times 10^{-4}}{0.0200} = 0.1316 \text{ molL}^{-1} \\ c(\text{Fe}_2\text{SO}_4) &= 1/2 c(\text{Fe}^{2+}) &=& \mathbf{6.58 \times 10^{-2} \text{ molL}^{-1}} \end{aligned}$$



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4.

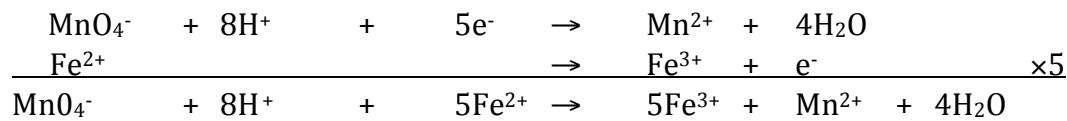


$$c = 0.0432 \text{ molL}^{-1} \quad v = 25.0 \text{ mL}$$

$$v = ? \quad c(\text{Cl}^{-1}) = 2 c(\text{SnCl}_2) = 2(0.108 \text{ molL}^{-1}) = 0.216 \text{ molL}^{-1}$$

$$\begin{aligned}
n(\text{MnO}_4^-) &= 2/10 n(\text{Cl}^-) \\
&= 2/10 (c \times v) \\
&= 2/10 (0.216)(0.0250) &= 0.00108 \text{ mol} \\
v(\text{MnO}_4^-) &= \frac{n}{c} = \frac{0.00108}{0.0432} &= 2.50 \times 10^{-2} \text{ L} = \mathbf{25.0 \text{ mL}}
\end{aligned}$$

5.



$$c = 0.0200 \text{ molL}^{-1}$$

$$\begin{aligned}
n[(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}] &= M[(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}] \\
&= (14 + 4(1.008))2 &= 36.064 \\
&= m/M &= 55.85 \\
&= \underline{1.03} &= (32.06 + 64)2 &= 192.12 \\
&392.13 &= 6(2.016 + 16) &= \underline{108.096} \\
&= 0.00263 & &= 392.13
\end{aligned}$$

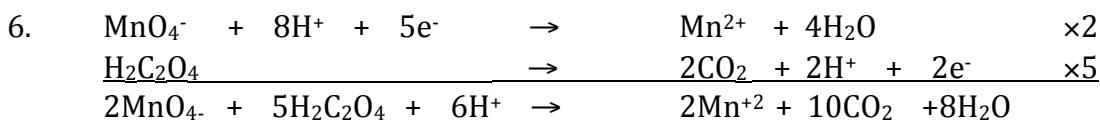
$$n(\text{Fe}^{2+}) = 0.00263 \text{ mol}$$

$$\begin{aligned}
n(\text{MnO}_4^-) &= 1/5 n(\text{Fe}^{2+}) \\
&= 0.000525 \text{ mol}
\end{aligned}$$

$$v(\text{MnO}_4^-) = n/c = \frac{0.000520}{0.0200} = 0.0263 \text{ L} \quad (\mathbf{26.3 \text{ mL}})$$



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$$v = 25 \text{ mL} \quad ?$$

$$c = 0.0192 \text{ mol L}^{-1}$$

$$\begin{aligned}
 n(\text{H}_2\text{C}_2\text{O}_4) &= \frac{5}{2} n(\text{MnO}_4^-) \\
 &= \frac{5}{2} (c \times v) \\
 &= \frac{5}{2} (0.0192 \times 0.0250) \\
 &= 0.0012 \text{ mol}
 \end{aligned}$$

$$\begin{aligned}
 m(\text{H}_2\text{C}_2\text{O}_4) &= n \times M \quad M(\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}) = 2 + 24 + 64 + 36 \\
 &= 126 \\
 &= (0.0012)(126) \\
 \mathbf{m(\text{H}_2\text{C}_2\text{O}_4)} &= \mathbf{0.151 \text{ g}}
 \end{aligned}$$



$$v = 20.0 \text{ mL}$$

$$v = 5.60 \times 10^2 \text{ mL}$$

at STP = 0.560 L

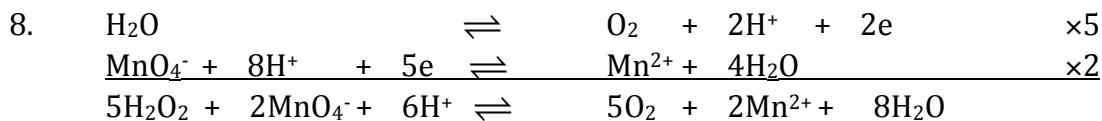
$$n(\text{CO}_2) = v / 22.4 \text{ L} = 0.560 / 22.4 = 0.025 \text{ mol}$$

$$\begin{aligned}
 (a) \quad n(\text{H}_2\text{C}_2\text{O}_4) &= \frac{5}{10} n(\text{CO}_2) = 0.0125 \text{ mol} \\
 c(\text{H}_2\text{C}_2\text{O}_4) &= n/v = \frac{0.0125}{0.0350} = \mathbf{0.357 \text{ mol L}^{-1}}
 \end{aligned}$$

$$\begin{aligned}
 (b) \quad n(\text{MnO}_4^-) &= \frac{2}{10} n(\text{CO}_2) = \frac{2}{10} (0.0250) = 0.00500 \text{ mol} \\
 c(\text{MnO}_4^-) &= n/v = \frac{0.00500}{0.0200} = \mathbf{0.250 \text{ mol L}^{-1}}
 \end{aligned}$$



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$$1 \text{ mL, } 3\% \quad c = 0.0205 \text{ molL}^{-1}$$

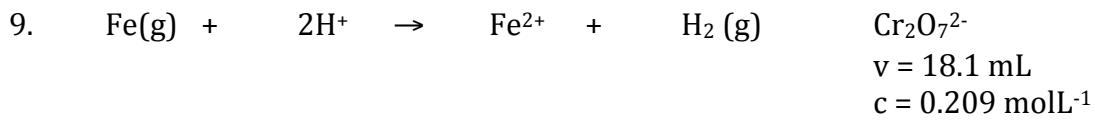
$$\text{Density } \rho = 1.00 \text{ g mL}^{-1} \quad v = ?$$

$$\rho = m/v = m(\text{H}_2\text{O}_2) = 0.0300 \text{ g mL}^{-1} \text{ in / mL of 3\%}$$

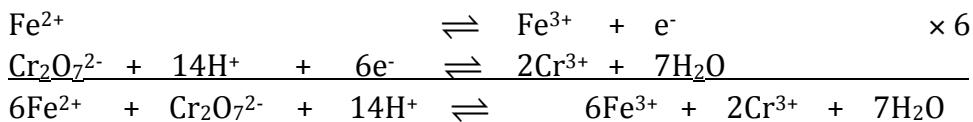
$$n(\text{H}_2\text{O}_2) = m/M = \frac{0.0300}{34} = 8.82 \times 10^{-4} \text{ mol}$$

$$n(\text{MnO}_4^-) = 2/5 n(\text{H}_2\text{O}_2) = 2/5 (8.82 \times 10^{-4}) = 3.53 \times 10^{-4} \text{ mol}$$

$$v(\text{MnO}_4^-) = n/c = \frac{3.53 \times 10^{-4}}{0.0205} = 0.0172 \text{ L (17.2 mL)}$$



$$\begin{array}{ccc} (\text{beaker}) & \rightarrow & (\text{beaker}) \\ 1.63 \text{ g Fe} & & v = 250 \text{ mL} \\ \% \text{ Iron in wire?} & & v = 20 \text{ mL} \end{array}$$



$$n(\text{Cr}_2\text{O}_7^{2-}) = c \times v = (0.209)(0.0181) = 3.78 \times 10^{-4} \text{ mol}$$

$$n(\text{Fe}^{2+} \text{ in 20 mL}) = 6 \times n(\text{Cr}_2\text{O}_7^{2-}) = 2.27 \times 10^{-3} \text{ mol}$$

$$c(\text{Fe}^{2+} \text{ in 20 mL}) = n/v = 0.1135 \text{ molL}^{-1}$$

$$\begin{array}{rcl} n(\text{Fe}^{2+} \text{ in 250 mL}) & = c \times v & = (0.1135)(0.250) \\ & & = 0.02837 \text{ mol} \\ & & = n(\text{Fe}) \text{ in the wire} \end{array}$$

$$m(\text{Fe}) \text{ in wire} = n \times M = 0.02837 \times 55.85 = 1.5846 \text{ g}$$

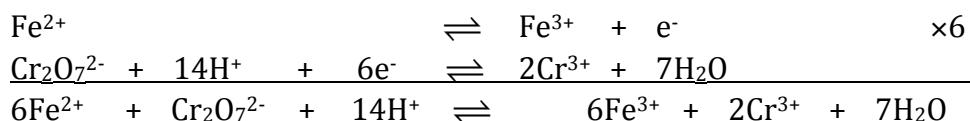
$$\% \text{ mass iron in wire} = \frac{m(\text{Fe})}{m(\text{wire})} \times 100$$

$$\begin{array}{rcl} & m(\text{wire}) & \\ & = \frac{1.5846}{1.63} \times 100 & = 97.2\% \end{array}$$



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10. Cr mineral
 $\rightarrow \text{Cr}_2\text{O}_7^{2-}$
1.27 g % Cr?



$$n(\text{Fe}^{2+}) = c \times v = (0.400)(0.0375) = 0.0150 \text{ mol}$$

$$n(\text{Cr}_2\text{O}_7^{2-}) = 1/6 n(\text{Fe}^{2+}) = 0.00250 \text{ mol}$$

$$n(\text{Cr}) = 2n(\text{Cr}_2\text{O}_7^{2-}) = 0.00500 \text{ mol}$$

$$m(\text{Cr}) = n \times M = (0.00500)(52) = 0.260 \text{ g}$$

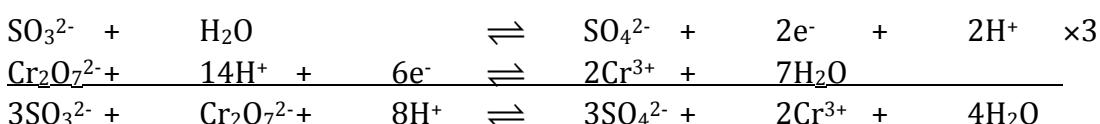
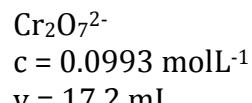
% mass Cr in mineral

$$= \frac{\text{man Cr}}{\text{man mineral sample}} \times 100\%$$

$$= \frac{0.260}{1.27} \times 100$$

$$= 20.5\%$$

11. Impure Na_2SO_3
0.752 g



$$n(\text{Cr}_2\text{O}_7^{2-}) = c \times v = (0.0993)(0.0172) = 0.00171 \text{ mol}$$

$$n(\text{SO}_3^{2-}) = 3n(\text{Cr}_2\text{O}_7^{2-}) = 0.00512 \text{ mol}$$

$$\begin{array}{lcl} n(\text{Na}_2\text{SO}_3) & = n \times M & M = 2(23) + 32 + 48 \\ & = (0.00512)(126) & = 126 \\ & = 0.646 \text{ g} & \end{array}$$

% purity of the sodium sulfite

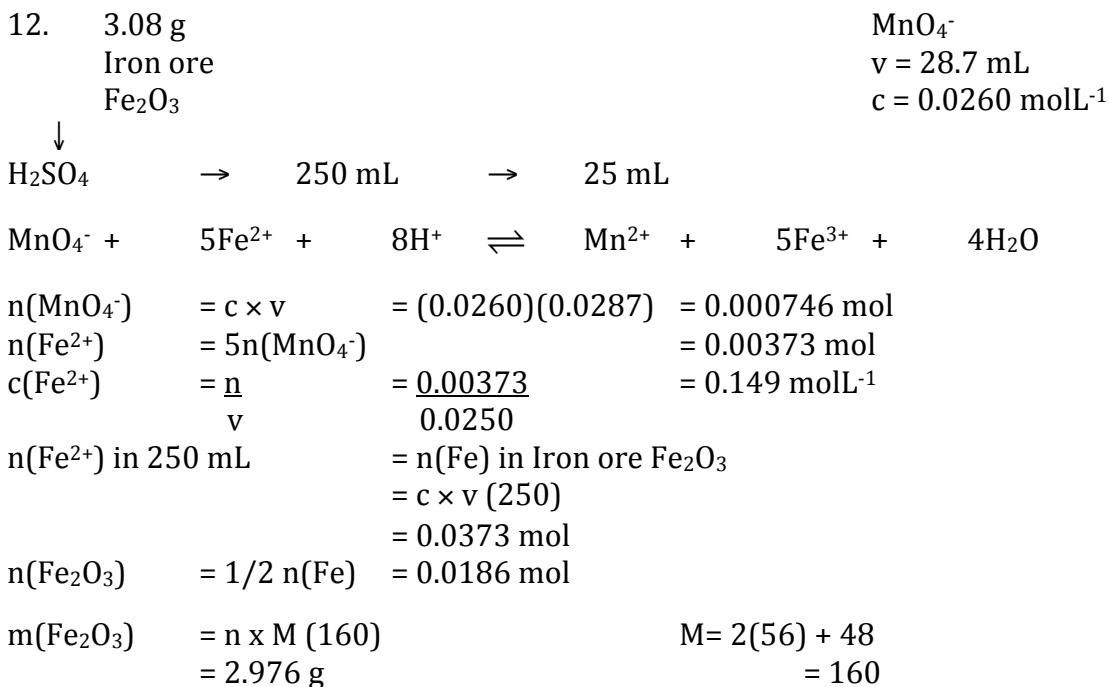
$$= \frac{m}{\text{m sample}} \times 100$$

$$= \frac{0.646}{0.752} \times 100$$

$$= 85.9\%$$

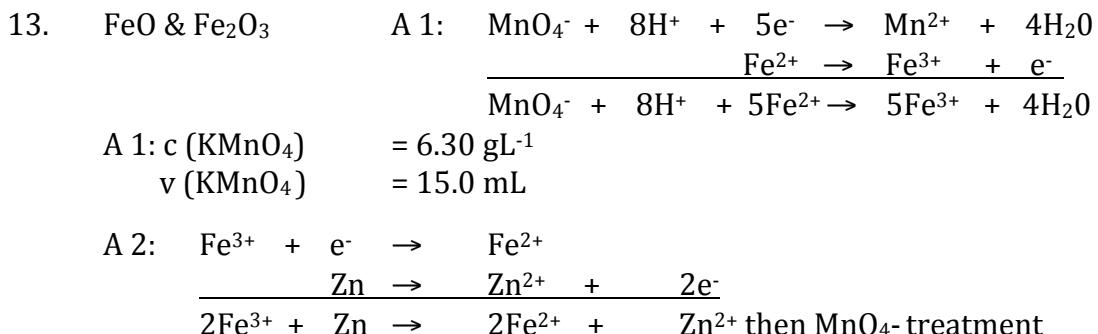


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% Fe_2O_3 in the iron ore

$$= \frac{m(\text{Fe}_2\text{O}_3)}{m(\text{ore})} \times 100 = \frac{2.976}{3.08} \times 100 = 96.6 \%$$



$$\begin{array}{lcl} \text{A 2: } v(\text{KMnO}_4) & = 25.1 \text{ mL} \\ M(\text{KMnO}_4) & = 158 \text{ g/mol} \\ M(\text{FeO}) & = 71.8 \text{ g/mol} \\ M(\text{Fe}_2\text{O}_3) & = 159.6 \text{ g/mol} \end{array}$$

Aliquot 1: $c(\text{KMnO}_4) = \frac{6.30 \text{ (g L}^{-1})}{M \text{ (gmol}^{-1})} = \frac{6.30}{158} = 0.03987 \text{ mol L}^{-1}$

$$n(\text{MnO}_4^-) = cV = 0.03987 \times 0.0250 = 9.968 \times 10^{-4} \text{ mol}$$

$$\begin{array}{lll} \text{Eqn. } n(\text{Fe}^{2+}) & = 5 \times n(\text{MnO}_4^-) & = 5(9.968 \times 10^{-4}) = 4.984 \times 10^{-3} \text{ mol} \\ n(\text{FeO}) & = n(\text{Fe}^{2+}) & = 4.984 \times 10^{-3} \text{ mol} \\ m(\text{FeO}) \text{ in aliquot 1} & = nM & = 4.984 \times 10^{-3} \times 71.8 = 0.2147 \text{ g} \end{array}$$



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$$m(\text{FeO}) \text{ in original sample} = 2 \times 0.2147 = 0.429 \text{ g}$$

Mass of FeO = **0.429 g**

Aliquot 2: $n(\text{MnO}_4^-) = cV = \frac{6.30}{158} \times 0.0251 \text{ mol} = 0.00100 \text{ mol}$

Eqn. $n(\text{Fe}^{2+}) = 5 \times n(\text{MnO}_4^-) = 5 (0.00100) = 5.00 \times 10^{-3} \text{ mol}$

This represents ALL Fe^{2+} & Fe^{3+} that was changed to Fe^{2+}
 $n(\text{Fe}^{3+})$ present = total $n(\text{Fe}) - n(\text{Fe}^{2+})$ determined from aliquot 1
 $= 5.00 \times 10^{-3} - 2.99 \times 10^{-3}$
 $= 2.01 \times 10^{-3} \text{ mol}$

$$4\text{Fe}^{3+} + 6\text{O}^{2-} \rightarrow 2\text{Fe}_2\text{O}_3$$

$$n(\text{Fe}_2\text{O}_3) = \frac{2}{4} n(\text{Fe}^{3+}) = 1.005 \times 10^{-3} \text{ mol}$$

$$m(\text{Fe}_2\text{O}_3) \text{ in aliquot} = 1.005 \times 10^{-3} \times 159.6 = 1.60 \times 10^{-1} \text{ g}$$

$$m(\text{Fe}_2\text{O}_3) \text{ in original sample} = 2 \times 1.60 \times 10^{-1} = 0.321 \text{ g}$$

Mass of Fe₂O₃ = **0.321 g**

14. $v(\text{Bleach}) = 10.0 \text{ mL}$ 1. $\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{I}_2 + \text{Cl}^- + \text{H}_2\text{O}$
then made up to 100.0 mL 2. $2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$

$$v(\text{aliquot}) = 25.0 \text{ mL} \quad n(\text{S}_2\text{O}_3^{2-}) = cV = 0.845 \times 0.0179 \text{ mol}$$

$$c(\text{Na}_2\text{S}_2\text{O}_3) = 0.845 \text{ M} \quad \text{Eqn. 2. } n(\text{I}_2) = \frac{1}{2} n(\text{S}_2\text{O}_3^{2-}) = \frac{1}{2} \times 0.845 \times 0.0179$$

$$v(\text{Na}_2\text{S}_2\text{O}_3) = 17.9 \text{ mL} \quad \text{Eqn. 1. } n(\text{ClO}^-) = n(\text{I}_2) = \frac{0.845 \times 0.0179}{2} \text{ in 25.0 mL}$$

$$\rho(\text{Bleach}) = 1.00 \text{ g.mL}^{-1} \quad n(\text{ClO}^-) \text{ in original 10 mL} = \frac{100 \times 0.845 \times 0.0179}{25} \text{ mol}$$

$$M(\text{NaOCl}) = 74.5 \text{ g/mol} \quad m(\text{NaOCl}) = nM$$

Since = 1.00 g/mL, 10 mL sample weighs 10.0 g

$$\% \text{ purity} = \frac{100 \times 0.845 \times 0.0179 \times 74.5 \times 100}{2 \times 25 \times 10}$$

$$= 22.54$$

Percentage purity of bleach = 22.5%