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Chemistry 205 Report

Redox Titration

Name:

Date: 22-02-2013

Purpose: 1. To learn a technique in volumetric analysis Redox titration
2. To review the stoichiometry of an oxidation - reduction reaction
3 To determine the concentration of an unknown sodium oxalate ($Na_2C_2O_4$) solution by titrating it against standardized potassium permanganate solution ($KMnO_4$)
4. To determine the percent by mass of Fe (II) in the form of Ferrous ammonium sulfate $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in a mixture by redox titration.

Part I

Table 1. Preparation of Standard $Na_2C_2O_4$ Solution

Mass of bottle + cap + + $Na_2C_2O_4$	10,0868 g ± 0.0001 g
Mass of empty bottle + cap	9,2768 g
Mass of $Na_2C_2O_4$	0,8100 g
Volume of solution	250,0 ml ± 0.1 ml

$n_{Na_2C_2O_4} = \frac{m}{M} = \frac{0,8100g}{134,00} = 6,045 \times 10^{-3}$ mol

$M_{Na_2C_2O_4} = \frac{n_{Na_2C_2O_4}}{V_{Na_2C_2O_4}} = \frac{6,045 \times 10^{-3}}{250,0} = 0,02418$ M

(2)

Table 2. Standardization of $KMnO_4$ Solution

Trial	Buret upper reading	Buret lower reading	Volume of $KMnO_4$ ±0,02 ml
1	0,00	26,60 ±0,02	26,60
2	0,00	26,80	26,80
3	0,00	26,20	26,20
Blank	0,00	0,40	0,40

$\bar{V}_{KMnO4} = 26,53$

$V_{KMnO4} = \bar{V}_{KMnO4} - V_{Blank}$
$= 26,53 - 0,4$
$= 26,13$ mL.

Ionic equation:

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

Volume of $Na_2C_2O_4$ = 25,00 ml.

Calculations: (show your work)

M of $KMnO_4$ = $9,254 \times 10^{-3}$ M

$\frac{n_{MnO_4^-}}{2} = \frac{n_{C_2O_4^{2-}}}{5}$

$\frac{(M \times V)_{MnO_4^-}}{2} = \frac{(M \times V)_{C_2O_4^{2-}}}{5}$

$M_{MnO_4^-} = \frac{2 \times 0,02418 \times 25,0 \times 10^{-3}}{...} = 9,254 \times 10^{-3}$ M.

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Table 3. Analysis of Unknown Oxalate

Unknown #: 5

Trial	Buret upper reading	Buret lower reading	Volume of $KMnO_4$ ml
1	0,00	27,50	27,50
2	0,00	27,30	27,30
3	0,00	27,10	27,10

$\overline{V}_{KMnO4}$ = 27,30

$V_{KMnO4} = \overline{V}_{KMnO4} - V_{Blank}$

= 27,30 − 0,40

= 26,9 ml.

Volume of unknown $Na_2C_2O_4$ = 25.00 mL ±0,02 ml

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Calculations: (show your work)

Molarity of unknown $Na_2C_2O_4$ =

$$\frac{(M \times V)_{MnO_4^-}}{2} = \frac{(M \times V)_{Na_2C_2O_4}}{5}$$

$$M_{Na_2C_2O_4} = \frac{5 \times 9{,}254 \times 10^{-3} \times 26{,}9 \times 10^{-3}}{2 \times 25{,}00 \times 10^{-3}} = 0{,}02489\,M$$

%error = 2 %

Part II

Table 4. Preparation of the Iron Unknown Solution

Unknown #: 12

Mass of bottle + cap + impure $Fe(NH_4)_2(SO_4)_2.6H_2O$	12,3927 ±0,0001
Mass of empty bottle + cap	10,3689
Mass of impure $Fe(NH_4)_2(SO_4)_2.6H_2O$	2,0238g
Volume of solution	100,0 mL ±0,1 ml

Table 5. Titration of the Iron Unknown Sample with $KMnO_4$ Solution

Trial	Buret upper reading	Buret lower reading	Volume of $KMnO_4$
1	0,00	5,80	5,80
2	5,80	11,70	5,90
3	11,70	17,30	5,60

$\overline{V}_{KMnO4}$ = 5,77 ml

Ionic equation:

$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

Calculations: (show your work)

Number of moles of Fe^{2+} (in titrated sample) = $\frac{n_{Fe^{2+}}}{5} = \frac{n_{MnO_4^-}}{1}$; $5(M \times V)_{MnO_4^-} = 5 \times 9,254 \times 10^{-3} \times 5,77 \times 10^{-3}$
$= 2,67 \times 10^{-4}$ mol.

Number of moles of $Fe(NH_4)_2(SO_4)_2.6H_2O$ (in titrated sample) = $n_{Fe^{2+}} = 2,67 \times 10^{-4}$ mol.

Number of moles of $Fe(NH_4)_2(SO_4)_2.6H_2O$ (in the original sample) = $n_{Fe(NH_4)_2(SO_4)_2.6H_2O} \times 10$ $= 2,67 \times 10^{-3}$ mol.

Mass of $Fe(NH_4)_2(SO_4)_2.6H_2O$ = $n \times M = 2,67 \times 10^{-3} \times 395,00$
$= 1,05$ g

% by mass of $Fe(NH_4)_2(SO_4)_2.6H_2O$ = $\frac{\text{mass of iron}}{\text{mass of powder}} \times 100 = \frac{1,05}{2,0238} \times 100$
$= 51,9\%$

good job

% error = 2.8 %

Questions

1. Give the oxidation number of the underlined atoms in the following species:
   a. $\underline{C}_2O_4^{2-}$ $2C + 4(-2) = -2 \Rightarrow C = +3$
   b. $Mg_3\underline{N}_2$ $3(+2) + 2N = 0 \Rightarrow N = -3$
   c. $H_3\underline{As}O_3$ $3(+1) + As + 3(-2) \Rightarrow As = +3$
   d. $\underline{W}O_4^{2-}$ $W + 4(-2) = -2 \Rightarrow W = +6$
   e. $\underline{Pt}Cl_6^{2-}$ $Pt + 6(-1) = -2 \Rightarrow Pt = +4$
   f. $\underline{Sb}F_6^-$ $Sb + 6(-1) = -1 \Rightarrow Sb = +5$

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2. SO_2 present in air is mainly responsible for the acid rain phenomenon. Its concentration can be determined by titrating against a standard permanganate solution in acidic media as follows:

   $SO_2 + MnO_4^- \rightarrow Mn^{2+} + SO_4^{2-}$

   a. Balance the above reaction, show your work.
   b. Calculate the number of grams of SO_2 in a sample of air if 7.37 ml of 0.00800 M $KMnO_4$ solution are required for titration.

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$(5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O) \times 2$

$(2H_2O + SO_2 \rightarrow SO_4^{2-} + 4H^+ + 2e^-) \times 5$

$10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$

$10H_2O + 5SO_2 \rightarrow 5SO_4^- + 20H^+ + 10e^-$

$2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 2Mn^{2+} + 5SO_4^- + 4H^+$

$\frac{5.896 \times 10^{-5}}{2} = \frac{n}{5}$