Topic 5 – Redox Stoichiometry

The stoichiometric method can be used to predict or analyze the quantity of a chemical involved in a chemical reaction

in buret Erlenmeyer flask

In a titration, one reagent (the *titrant*) is slowly added to another (the *sample*) until an abrupt change in a solution property (the *endpoint*) occurs

In redox titrations, the titrant is always a strong oxidizing or reducing agent.

Two oxidizing agents commonly used in redox titrations are acidic solutions of permanganate ions or dichromate ions.

They are both strong oxidizing agents and undergo a colour change when they oxidize a reducing agent in a sample being titrated

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

purple-pink colourless

Problem
What is the concentration of the potassium permanganate solution?

Design
A freshly prepared solution of potassium permanganate is titrated against samples of acidic tin(II) chloride solution, which has a known concentration. The tin(II) chloride solution is the primary standard.

Evidence

Table 1 Titration of 10.00 mL of Acidic 0.0500 mol/L $SnCl_2$(aq) with $KMnO_4$(aq)

Trial	~~1~~	2	3	4
final burette reading (mL)	~~18.4~~	35.3	17.3	34.1
initial burette reading (mL)	~~1.0~~	18.4	0.6	17.3
volume of $KMnO_4$(aq) (mL)	~~17.4~~	16.9	16.7	16.8
endpoint colour	~~dark pink~~	light pink	light pink	light pink

OA OA SOA OA OA

$Sn^{2+}_{(aq)}$ $Cl^-_{(aq)}$ $K^+_{(aq)}$ $MnO_{4(aq)}^-$ $H^+_{(aq)}$ $H_2O_{(l)}$

SRA RA RA RA

$2[8H^+_{(aq)} + MnO^-_{4(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

$5[Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-$

$16H^+_{(aq)} + \underline{2}MnO^-_{4(aq)} + \underline{5}Sn^{2+}_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 8H_2O_{(l)} + 5Sn^{4+}$

V: 16.8ml
= 0.0168L
n: 0.0002mol $\times \frac{2}{5}$
C: ??

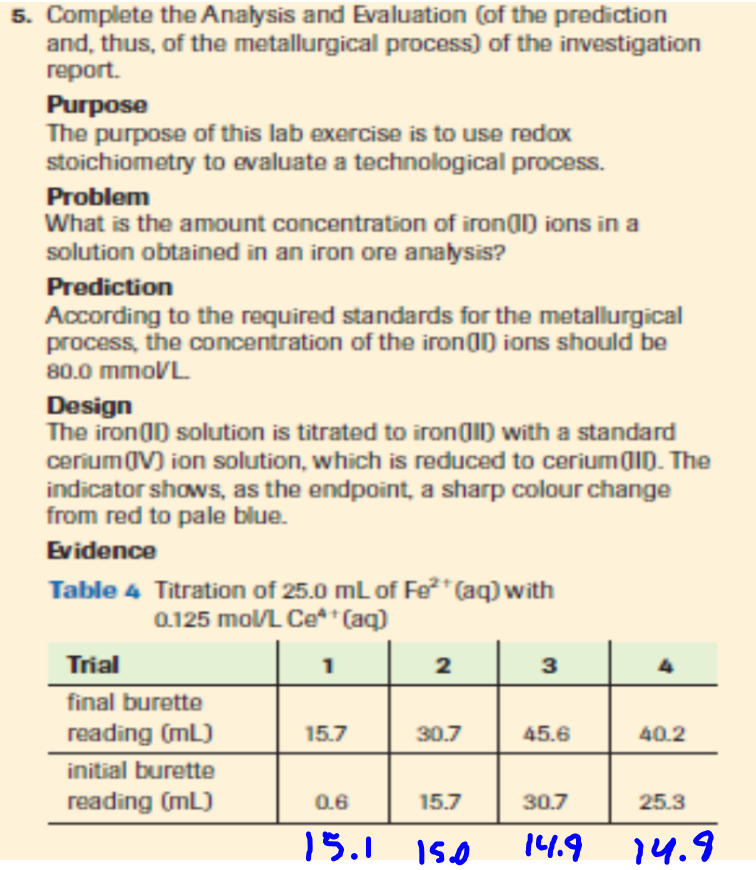
V= 10.00mL = 0.0100L
C: 0.0500mol/L
n = cv
= 0.0005 mol

$\boxed{n = cv}$

$C = \frac{n}{v}$

C: 0.01190...mol/L
$\boxed{C: 0.0119mol/L}$

11.9mmol/L



5. Complete the Analysis and Evaluation (of the prediction and, thus, of the metallurgical process) of the investigation report.

Purpose

The purpose of this lab exercise is to use redox stoichiometry to evaluate a technological process.

Problem

What is the amount concentration of iron(II) ions in a solution obtained in an iron ore analysis?

Prediction

According to the required standards for the metallurgical process, the concentration of the iron(II) ions should be 80.0 mmol/L.

Design

The iron(II) solution is titrated to iron(III) with a standard cerium(IV) ion solution, which is reduced to cerium(III). The indicator shows, as the endpoint, a sharp colour change from red to pale blue.

Evidence

Table 4 Titration of 25.0 mL of Fe^{2+}(aq) with 0.125 mol/L Ce^{4+}(aq)

Trial	1	2	3	4
final burette reading (mL)	15.7	30.7	45.6	40.2
initial burette reading (mL)	0.6	15.7	30.7	25.3
	15.1	15.0	14.9	14.9

$Fe^{2+} \rightarrow Fe^{3+} + 1e^-$

$Ce^{4+} + 1e^- \rightarrow Ce^{3+}$

$Fe^{2+}_{(aq)} + Ce^{4+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + Ce^{3+}_{(aq)}$

v: 25.0mL

n = ____ ← 1/1

$c = \frac{n}{v}$

= 0.074875...mol/L

$\boxed{= 0.0749 mol/L}$

c: 0.125mol/L

v: 14.975mL = 0.014975

n = cv

= 0.00187... mol

LAB EXERCISE 13.D

Analyzing for Chromium in Steel

Report Checklist

○ Purpose
○ Problem
○ Hypothesis
○ Prediction
○ Design
○ Materials
○ Procedure
○ Evidence
● Analysis
○ Evaluation

Stainless steel is a corrosion-resistant, esthetically pleasing alloy, normally composed of nickel, chromium, and iron. Complete the Analysis of the investigation report.

Purpose

The purpose of this lab exercise is to use the stoichiometric method in a redox chemical analysis.

Problem

What is the amount concentration of chromium(II) ions in a solution obtained in the analysis of a stainless steel alloy?

Design

A standard potassium dichromate solution is used as an oxidizing agent to oxidize chromium(II) ions to chromium(III) ions in an acidic solution (**Figure 4**).

Figure 4
The blue Cr^{2+}(aq) solution is oxidized to a green Cr^{3+}(aq) solution.

Evidence

Table 3 Titration of 10.00 mL of acidic Cr^{2+}(aq) with 0.125 mol/L $K_2Cr_2O_7$(aq)

Trial	1	2	3
final burette reading (mL)	17.5	34.9	18.9
initial burette reading (mL)	0.1	17.5	1.5
volume of $K_2Cr_2O_7$(aq) (mL)	17.4	17.4	17.4

SOA

OA SRA $Cr^{2+}_{(aq)}$ OA $K^{+}_{(aq)}$ $Cr_2O_7{}^{2-}_{(aq)}$ OA $H^{+}_{(aq)}$ OA RA $H_2O_{(l)}$

$$6\left[Cr^{2+}_{(aq)} \longrightarrow Cr^{3+}_{(aq)} + 1e^-\right.$$

$$14H^+_{(aq)} + 6e^- + Cr_2O_7{}^{2-}_{(aq)} \longrightarrow 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$$

$$6Cr^{2+}_{(aq)} + 14H^+_{(aq)} + Cr_2O_7{}^{2-}_{(aq)} \longrightarrow 8Cr^{3+}_{(aq)} + 7H_2O_{(l)}$$

v: 10.00ml   c   c: 0.125mol/L

v: 17.4mL

$n = 0.01305$ $\times \frac{6}{1}$

$n = cv$

$= 0.002175$mol

$c = \frac{n}{v}$

$= 1.305$mol/L

$= \boxed{1.31\text{mol/L}}$