



Ionic Reactions and Separations

EXPERIMENTS IN QUALITATIVE ANALYSIS

EDWARD J. KING

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Preface

When my textbook *Qualitative Analysis and Electrolytic Solutions* was published in 1959, qualitative analysis was taught as a separate second-year course in the chemistry curriculum. Since then it has been almost universally incorporated into the general chemistry course. Today, as students encounter qualitative analysis in the laboratory, they are attending lectures and reading chemistry textbooks that give them the basic principles of the theory of solutions, electrolytes, and chemical equilibrium. Therefore, *Ionic Reactions and Separations*, while reviewing aspects of these subjects, seeks more expressly to show their specific applications to qualitative analysis—applications that are necessarily slighted in the general chemistry textbook.

Chapter 1 surveys various types of ionic reactions and shows how their extent under standard conditions can be judged from the magnitudes of K , E° , or ΔG° . The sections on E° and ΔG° can be omitted or deferred until these properties have been reached in the class lectures. Chapter 2 treats the important ionic separations, both by verbal description and by numerical calculation.

Chapter 3 presents the techniques of the analytical laboratory, which are then used in the procedures of Chapter 4 dealing with the detection of the anion. The principles introduced in Chapter 1 and applied in Chapter 4 are reviewed in Chapter 5 in a programmed format designed for self-study by the student. Procedures for detecting the cation are given in Chapter 6.

The analysis of simple substances containing only one cation and one anion

presented in these chapters is an effective way to study ionic reactions. Therefore, courses in which only six weeks are assigned to qualitative analysis can use Chapter 1, parts of Chapter 2, and Chapters 3 through 6. Courses that have a full quarter or a term at their disposal can deal with the analysis of mixtures treated in Chapters 7 to 14.

The scheme of analysis for the cations given in *Qualitative Analysis and Electrolytic Solutions* has stood the test of time and has been modified in only a few details for its inclusion here. The original lengthy description of the chemistry of the ions has been replaced by a concise summary of the general characteristics of each group, but the discussion of the steps in the systematic analysis has been expanded so that the specific properties of the ions used in the analytical procedure are presented in some detail. Illustrative numerical calculations are also included to show the application of equilibrium principles to various steps in the procedure. In this book, the anion procedures have been simplified and the number of anions has been reduced from fifteen to eleven.

I take this opportunity to thank the many teachers and students whose comments and suggestions have been very helpful.

Edward J. King

To the Student

What is this white solid—baking powder or rat poison? Does that detergent contain phosphate? Can we detect manganese in this Etruscan sculpture and so prove that it is a forgery? Does this moon rock contain titanium? Such are the questions to which qualitative analysis can give a definite answer.

The true analyst, in contrast with the one-finger-in-the-book determinator, wants to know the principles on which his work is based. In qualitative analysis, he learns the practical implications and limitations of the theory of electrolytes. This is a mainstream of chemical interest that overflows into biochemistry, physiology, molecular biology, and geology. In qualitative analysis, for example, we use buffers to control separations between ions. The same principles of buffer action are important in regulating the acidity of body fluids. In qualitative analysis, we develop the principles governing the formation of precipitates. These principles apply also to formation of mollusk shells, to the deposition of calcium carbonate in the ocean or in caves, and to the creation of veins of sulfide minerals.

In the course of the laboratory work you, the analyst, will acquire experience with inorganic substances. The facts you learn may not seem important in themselves, but in the aggregate they constitute a reservoir of knowledge. With this experience you can independently interpret results and observations; without it you are forced to rely on the opinions and interpretations of others. You may ultimately forget much of this specific information about inorganic substances, especially if you study no more chemistry, but you will have ex-

perienced how scientists use knowledge gained by first-hand observations to shape their thought.

Scientific work is not required to be dull! Qualitative analysis will excite your sense of wonder. Add ammonia to a green solution of a nickel salt and watch it suddenly turn blue. Mix colorless solutions of an antimony salt and a sulfide and see a beautiful bright orange solid appear.

Qualitative analysis can be dull and routine if you choose to be a "cookbook" chemist. Or it can be enjoyable and satisfying if you keep your eyes open, develop your powers of deduction, and learn to be resourceful in dealing with the puzzling observation that does not jibe with your preconception or with some statement in this book.

Contents

PRINCIPLES, 1

One. Ionic Reactions	3
1.1 Electrolyte Solutions	3
1.2 Evidence for Chemical Reaction	4
1.3 Types of Reactions	4
1.4 Ionic Equations	7
1.5 Proton Transfer Reactions	8
1.6 The Extent of Proton Transfer Reactions	10
1.7 Precipitation Reactions	11
1.8 The Solubility Product and Extent of Reaction	13
1.9 Formation of Complex Ions	14
1.10 Systematic Inorganic Chemistry. Reactions of Silver(I) Ion	16
1.11 Redox Reactions. Oxidation Numbers	16
1.12 Balancing Equations for Redox Reactions	19
1.13 The Extent of Redox Reactions	22
1.14 Gibbs Energy Changes and the Extent of Reaction	23
Exercises	24

Two. Ionic Separations	27
2.1 Introduction	27
2.2 Fractional Precipitation of Sulfates	27
2.3 Precipitation from Homogeneous Medium	29
2.4 Precipitation of Sulfides by Hydrogen Sulfide. Control of the Sulfide Ion Concentration	30
2.5 Precipitation of Sulfides by Thioacetamide	32
2.6 Numerical Calculations for the Precipitation of Sulfides	33
2.7 Precipitation of Hydroxides. Control of the Hydroxide Ion Concentration	34
2.8 Numerical Calculations for the Precipitation of Hydroxides	36
2.9 Separations by Control of Carbonate and Chromate Ion Concentrations	37
2.10 Control of Metal Ion Concentrations by Complex Formation	38
2.11 Numerical Calculations for Complex Formation	38
2.12 Separation by Selective Redox Reactions	40
2.13 Separation by Physical Methods. Distribution Equilibria	40
Exercises	41

TECHNIQUES, 45

Three. The Laboratory Work in Qualitative Analysis	47
3.1 Preliminary Work	47
3.2 General Remarks About the Laboratory Work	49
3.3 The Techniques of Semimicro Qualitative Analysis	50
T-1. Sampling, 50. T-2. Dissolving the Sample, 50. T-3. Measuring Quantity, 50. T-4. Adding Reagents, 52. T-5. Mixing, 52. T-6. Heating Solutions, 52. T-7. Evaporating Solutions, 53. T-8. Centrifugation, 54. T-9. Separating the Super- natant Solution from the Precipitate, 54. T-10. Washing Precipitates, 54. T-11. Transferring Precipitates, 55. T-12. Testing the Acidity, 55.	
3.4 The Laboratory Notebook	55

ANALYSIS OF SIMPLE SUBSTANCES, 57

Four. Detection of the Anion	59
4.1 Introduction	59
4.2 Preparation of a Sample for Analysis	60

4.3 Elimination Tests	61
ET-1. Test for Strongly Acidic or Basic Anions, 61. ET-2. Test for Volatile or Unstable Acids, 61. ET-3. Test for Strong Reducing Substances, 61. ET-4. Test for Strong Oxidizing Agents, 61. ET-5. Test for Anions that Form Insoluble Silver Salts, 62. ET-6. Test for Anions that Form Insoluble Calcium Salts, 62. ET-7. Test for Anions that Form Insoluble Barium Salts, 62.	
4.4 Practice on Known Samples	62
4.5 Identification Tests	63
(a) Identification of Fluoride Ion, F^- , 63. (b) Identification of Chloride Ion, Cl^- , 64. (c) Identification of Bromide Ion, Br^- , 64. (d) Identification of Iodide Ion, I^- , 64. (e) Identification of Sulfide Ion, S^{2-} , 65. (f) Identification of Sulfite Ion, SO_3^{2-} , 65. (g) Identification of Sulfate Ion, SO_4^{2-} , 65. (h) Identification of Nitrite Ion, NO_2^- , 65. (i) Identification of Nitrate Ion, NO_3^- , 66. (j) Identification of Phosphate Ion, PO_4^{3-} , 66. (k) Identification of Carbonate Ion, CO_3^{2-} , 67.	
4.6 Analysis of a Soluble Salt	68
4.7 Analysis of Other Salts	68
Five. Principles of Anion Analysis	69
5.1 Introduction	69
PROTON TRANSFER REACTIONS	70
5.2 Acids and Bases	70
5.3 Reactions of Univalent Anions with Water (ET-1)	71
5.4 Reactions of Bivalent and Tervalent Anions with Water (ET-1)	74
5.5 Reactions of Ampholytic Anions with Water (ET-1)	77
5.6 Formation of Unstable or Volatile Acids. Proton Transfer (ET-2)	79
Review Exercises	81
REDOX REACTIONS	82
5.7 Formation of Unstable or Volatile Acids. Redox (ET-2)	82
5.8 Test for Strong Reducing Substances. The Reduction Half-Reaction (ET-3)	84
5.9 Test for Strong Reducing Substances. The Oxidation Half-Reaction (ET-3)	87
5.10 Test for Strong Reducing Substances. Oxidation of Sulfide and Sulfite (ET-3)	89
5.11 Test for Strong Reducing Substances. Oxidation of Nitrite (ET-3)	93
5.12 Test for Strong Oxidizing Agents (ET-4)	95
Review Exercises	97
PRECIPITATION REACTIONS	98
5.13 Precipitation of Insoluble Silver Salts (ET-5)	98
5.14 Dissolution of Insoluble Silver Salts (ET-5)	101

5.15	Precipitation and Dissolution of Insoluble Calcium Salts (ET-6)	103
5.16	Precipitation of Insoluble Barium Salts (ET-7)	105
	Review Exercises	105
Six.	Detection of the Cation	107
6.1	Introduction	107
6.2	Initial Examination	108
	(a) Physical Appearance of the Sample, 108. (b) Flame Tests, 108.	
6.3	Preparation of the Solution	109
	(a) Choice of Solvent, 109. (b) Color Differences Between Solid and Solution, 110. (c) Cation-Anion Incompatibilities, 110. (d) Removal of Interfering Anions, 110.	
6.4	Preliminary Tests	111
	(a) Action of Excess Sodium Hydroxide, 111. (b) Action of Excess Aqueous Ammonia, 111. (c) Action of Sulfuric Acid, 112. (d) Action of Thioacetamide in Acidic Solution, 112. (e) Action of Thioacetamide in Basic Solution, 113.	
6.5	Identification Tests	113
	Aluminum(III) Ion, 113. Ammonium Ion, 114. Antimony(III) Ion, 114. Arsenic(III) Ion, 114. Barium(II) Ion, 115. Bismuth(III) Ion, 115. Cadmium(II) Ion, 115. Calcium(II) Ion, 115. Chromium(III) Ion, 116. Cobalt(II) Ion, 116. Copper(II) Ion, 116. Iron(II) and Iron(III) Ions, 117. Lead(II) Ion, 117. Magnesium(II) Ion, 118. Manganese(II) Ion, 118. Mercury(I) and Mercury(II) Ions, 119. Nickel(II) Ion, 119. Potassium(I) Ion, 119. Silver(I) Ion, 120. Sodium(I) Ion, 120. Strontium(II) Ion, 121. Tin(II) and Tin(IV) Ions, 121. Zinc(II) Ion, 121.	
6.6	Some Applications of Chemical Microscopy	122
	Exercises	123
 SYSTEMATIC ANALYSIS OF MIXTURES, 125		
Seven.	Cation Group 1.	
	The Hydrochloric Acid Group: Ag^+, Hg_2^{++}, Pb^{++}	129
7.1	Properties of the Ions	129
7.2	Precipitation of the Group	131
7.3	Separation and Identification of the Ions	132
7.4	Illustrative Numerical Calculations	133
	(a) The Relation Between Solubility and Solubility Product, 133. (b) Solubility and Complex Formation, 134. (c) Disproportionation of Mercury(I), 136.	
	EXPERIMENTAL PART	138
7.5	Analysis of Known and Unknown Solutions	138
	OUTLINE 1. The Systematic Analysis of Cation Group 1	139
	Exercises	141

Eight. Cation Group 2. The Acid Hydrogen Sulfide Group: Hg⁺⁺, Pb⁺⁺, Bi³⁺, Cu⁺⁺, Cd⁺⁺, As(III), As(V), Sb(III), Sb(V), Sn(IV), Sn⁺⁺	143
8.1 Introduction	143
8.2 Some Features of the Group as a Whole	144
8.3 Precipitation of the Group	144
8.4 Subdivision of the Group	145
8.5 Separation and Identification of Mercury	145
8.6 Separation and Identification of Lead	146
8.7 Separation and Identification of Bismuth	147
8.8 Identification of Copper and Cadmium	147
8.9 Subdivision of the Sulfides of the Arsenic Section	148
8.10 Identification of Arsenic	148
8.11 Identification of Antimony	149
8.12 Identification of Tin	149
8.13 Illustrative Numerical Calculations	150
(a) Fractional Precipitation of Sulfides, 150. (b) Subdivision of the Group, 150. (c) Dissolution of Sulfides in Nitric Acid, 151. (d) Separation by Complex Formation, 152.	
EXPERIMENTAL PART	153
8.14 Analysis of Known and Unknown Samples	153
8.15 Preliminary Preparations	153
P-1. Calibration of a Test Tube, 153. P-2. Oxidation of Tin(II), 153. P-3. Adjust- ment of Acidity, 153.	
OUTLINE 2. Precipitation and Subdivision of Cation Group 2	154
OUTLINE 3. The Systematic Analysis of the Copper Section of Cation Group 2	156
OUTLINE 4. The Systematic Analysis of the Arsenic Section of Cation Group 2	158
Exercises	160
 Nine. Cation Group 3. The Basic Hydrogen Sulfide Group: Al³⁺, Cr³⁺, Fe³⁺, Fe⁺⁺, Mn⁺⁺, Co⁺⁺, Ni⁺⁺, Zn⁺⁺	 163
9.1 Introduction	163
9.2 Structures of the Ions	164
9.3 Some Characteristics of the 2+ Oxidation State	166
9.4 Some Characteristics of the 3+ Oxidation State	167
9.5 Preliminary Tests for the Ions	168
9.6 Precipitation of the Group	169
9.7 Separation and Identification of Manganese	170

9.8 Subdivision of the Group	171
9.9 Identification of Iron, Cobalt, and Nickel	171
9.10 Identification of Chromium	172
9.11 Separation and Identification of Aluminum	172
9.12 Identification of Zinc	173
9.13 Some Numerical Illustrations	173
(a) The Chromate–Dichromate Relationship, 173. (b) Oxidation of Cobalt(II), 174.	
EXPERIMENTAL PART	175
9.14 Analysis of Known and Unknown Samples	175
9.15 Preliminary Tests	176
PT-1. Tests for Fe, 176. PT-2. Test for Ni, 176. PT-3. Test for Mn, 177. PT-4. Test for Co, 177. PT-5. Test for Zn, 177.	
OUTLINE 5. The Systematic Analysis of Cation Group 3	178
Exercises	180
Ten. Cation Group 4.	
The Ammonium Carbonate Group: Ca^{++}, Sr^{++}, Ba^{++}	183
10.1 Introduction	183
10.2 Some Properties of the Ions	184
10.3 Precipitation of the Group	185
10.4 Separation and Identification of Barium	187
10.5 Separation and Identification of Calcium and Strontium	188
10.6 Some Numerical Illustrations	189
(a) Ammonium Carbonate Solution, 189. (b) Solubility of Calcium Oxalate and pH, 190.	
EXPERIMENTAL PART	192
10.7 Analysis of Known and Unknown Samples	192
10.8 Flame Tests	192
OUTLINE 6. The Systematic Analysis of Cation Group 4	194
Exercises	196
Eleven. Cation Group 5.	
The Soluble Group: Na^+, K^+, Mg^{++}, NH_4^+	198
11.1 Introduction	198
11.2 General Characteristics of Sodium and Potassium Ions	199
11.3 Detection of Sodium	200
11.4 Detection of Potassium	200
11.5 Some Properties of Magnesium Ion	202
11.6 Separation and Detection of Magnesium	202

11.7	Some Properties of Ammonium Ion and Its Detection	203
11.8	A Numerical Example	203
	Precipitation of Magnesium Ammonium Phosphate, 204.	
	EXPERIMENTAL PART	205
11.9	Analysis of Known and Unknown Samples	205
11.10	Flame Tests	206
	OUTLINE 7. The Systematic Analysis of Cation Group 5	207
	Exercises	209
Twelve.	Analysis of Alloys and General Cation Unknowns	210
12.1	Preparation of a Solution of an Alloy. Principles	210
12.2	Preparation of a Solution of an Alloy. Procedure	211
	(a) Preliminary Solubility Tests, 211. (b) Dissolution of the Alloy, 212. (c) Preparation of the Solution for Cation Analysis, 212. (d) Treatment of the White Residue from Step (c), 212.	
12.3	Analysis of General Cation Unknowns	213
	OUTLINE 8. The Sulfate Separation of Cation Group 4	215
	Exercises	216
Thirteen.	Analysis of Mixtures for Anions	217
13.1	Introduction	217
13.2	Preparation of a Solution for Analysis	218
13.3	Elimination Tests	218
	Modified Elimination Test ET-5 for Anions that Form Insoluble Silver Salts, 218.	
13.4	Identification Tests	219
	(a) Identification of Fluoride Ion, 219. (b) Separation and Identification of Chloride, Bromide, and Iodide Ions, 219. (c) Identification of Sulfide Ion, 220. (d) Identification of Sulfite and Sulfate Ions, 220. (e) Identification of Nitrite Ion, 221. (f) Identification of Nitrate Ion, 221. (g) Identification of Phosphate Ion, 221. (h) Identification of Carbonate Ion, 222.	
13.5	Analysis of a Known Mixture	223
	Exercises	223
Fourteen.	Analysis of Mixtures for Cations and Anions	224
14.1	Preliminary Examination	224
	(a) Preparation of the Sample, 224. (b) Flame Tests, 224. (c) Solubility Tests, 225. (d) Other Preliminary Tests, 225.	
14.2	Analysis for Anions	225
14.3	Preparation of a Solution for Cation Analysis	225
14.4	Treatment of Insoluble Residues	226

APPENDIXES, 227

A.1	Summary of Solubilities	229
A.2	Solubility Products at 25°C	230
A.3	Acidity and Basicity Constants at 25°C	232
A.4	The Ion Product of Water at Various Temperatures	233
A.5	The Ion Product of Hydrogen Sulfide	233
B.1	Reagent Solutions	234
B.2	Solutions. Directions and Comments	236
B.3	Solid and Pure Liquid Reagents	237
B.4	Test Papers	237
B.5	Standard Solutions of the Ions	238
C	Apparatus	239
D	Four-Place Logarithms	240
	Table of Atomic Weights	242
	Answers to Numerical Problems	243
Index		245

Principles

