

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
	Literature	2
<b>2</b>	<b>The Math Behind the pH-log<i>c<sub>i</sub></i> Diagrams</b>	<b>5</b>
	Literature	18
<b>3</b>	<b>Constructing pH-log<i>c<sub>i</sub></i> Diagrams</b>	<b>19</b>
3.1	Monobasic Acids	19
3.2	Dibasic Acids	22
3.3	Tribasic Acids	25
3.4	Tetrabasic Acids	29
<b>4</b>	<b>The Application of pH-log<i>c<sub>i</sub></i> Diagrams for Graphical Estimation of the pH of Solutions and for the Derivation of Useful Simplified Equations</b>	<b>33</b>
4.1	Monobasic Acids and Their Corresponding Bases	36
4.1.1	Very Strong Acids and Their Corresponding Very Weak Bases	36
4.1.2	Strong Acids and Their Corresponding Weak Bases	40
4.1.3	Weak Acids and Their Corresponding Strong Bases	46
4.1.4	Very Weak Acids and Their Corresponding Very Strong Bases	51
4.1.5	Ranges of Validity of the Simplified Equations for Monobasic Acids	55
4.2	Dibasic Acids, Ampholytes, and Diacidic Bases	56
4.2.1	Dibasic Acids	56
4.2.2	Simplified Equation for Ampholytes	62
4.2.3	Diacidic Bases	68
4.3	Salt Solutions with Protolyzing Anions and Cations	72
4.4	Examples	76
4.4.1	The pH-log <i>c<sub>i</sub></i> Diagram of Water	76
4.4.2	Acetic Acid/Acetate	77
4.4.3	Hydrogen Sulfide	78

4.4.4	Phosphoric Acid . . . . .	79
4.4.5	Ascorbic Acid . . . . .	80
4.4.6	Acetylsalicylic Acid . . . . .	81
4.4.7	Benzoic Acid . . . . .	83
4.4.8	Glycine . . . . .	84
4.4.9	Aspartic Acid . . . . .	85
4.4.10	Ethylenediaminetetraacetic Acid (EDTA) . . . . .	86
	Literature . . . . .	88
<b>5</b>	<b>The Use of pH-log<sub>c</sub>i Diagrams for the Construction of Titration Diagrams . . . . .</b>	<b>89</b>
5.1	Titration of Hydrochloric Acid of Various Concentrations with Sodium Hydroxide Solution . . . . .	91
5.2	Titration of Sodium Hydroxide Solution with Hydrochloric Acid . . . . .	93
5.3	Titration of Different Concentrations of Acetic Acid with Sodium Hydroxide . . . . .	94
5.4	Titration of Moderately Strong Acids Having Different pK <sub>a</sub> Values with Sodium Hydroxide . . . . .	96
5.5	Titration of Sulfuric Acid . . . . .	98
5.6	Titration of Dibasic Amino Acids . . . . .	99
5.7	Comparison of the Titrations of an Acid and its Corresponding Base: (a) Ammonium Ions with Sodium Hydroxide, (b) Ammonia with Hydrochloric Acid . . . . .	100
<b>6</b>	<b>Titration Errors . . . . .</b>	<b>103</b>
6.1	Systematic Titration Errors . . . . .	103
6.1.1	Systematic Titration Errors in Titrations of Acids with pK <sub>a</sub> Values Between 0 and 14 with Very Strong Bases (e.g., NaOH) . . . . .	104
6.1.2	Systematic Titration Errors of Titrations of Bases with pK <sub>b</sub> Values Between 0 and 14 with a Very Strong Acid (e.g., Hydrochloric Acid) . . . . .	106
6.1.3	Systematic Titration Errors of Titrations of Very Strong Acids with Very Strong Bases and Vice Versa . . . . .	108
6.2	Random Titration Errors . . . . .	110
	Literature . . . . .	111
	<b>Appendix A: Derivation of the Exact Functions and the Equations of the Asymptotes for Multibasic Acids . . . . .</b>	<b>113</b>
	<b>Index . . . . .</b>	<b>135</b>