CHAPTER 15

Microdetermination of Neutralization Equivalent, Ionic Hydrogen, or Carboxyl Groups

The number of grams of substance required to neutralize one liter of normal alkali is known as the neutralization equivalent.[32,86,120,121,132,163] It serves both as a determination of the acidic groups and of the molecular weight. The neutralization equivalent is equivalent to the molecular weight divided by the number of acid groups present. For example, the value for benzoic acid would be equal to the molecular weight, while that for phthalic acid would be one-half the molecular weight. The reactions involved may be represented by the following equations:

$$R'COOH + NaOH = R'COONa + H_2O$$

or

$$R''(COOH)_2 + 2NaOH = R''(COONa)_2 + 2H_2O$$

According to Kamm,[86] the determination gives good results for most carboxylic acids. One aromatic amino group in the molecule does not interfere appreciably, but more than one aromatic or one aliphatic amino group does interfere. Hydroxyl groups and even a single phenolic group, as in salicylic acid, do not interfere and give neutralization equivalents equal to the molecular weight. However, in general, the weakly acidic groups, like phenols, amides, and imides, give abnormally high neutralization equivalents. A strongly acidic phenol like *s*-tribromophenol may be titrated quantitatively in alcoholic solution using phenolphthalein as the indicator. Clark[32] has found that with hydroxyl groups the end point fades and the titration is best carried out rapidly. He also preferred to add an excess of alkali and back-titrate when dealing with lactones.

It must be borne in mind that *any* acid group may affect the determination. In fact, the same procedure may be used to determine halogens present as the hydrohalides, sulfur as the acid sulfate or sulfate, phosphorus as the phosphates, etc.

Besides phenolphthalein, thymolphthalein and thymol blue have been used as indicators. The general rules regarding the relationship of the pKa of the indicator and that of the substance to be titrated apply.[34,74] For example, where other titratable groups are present, the pKa of the *carboxyl* might be so low that an indicator such as bromocresol green may be required for titration of the *carboxyl* alone without interference of the other acidic groups present. Organic compounds having several acid groups are comparable to inorganic di- or tribasic acids, such as phosphoric acid.

In the absence of pKa data, type compounds are often helpful for test purpose to help the analyst choose an indicator.

Reagents

STANDARD SODIUM HYDROXIDE, 0.01N[1,50]

This is prepared and standardized according to the directions given in Chapter 5.

STANDARD HYDROCHLORIC ACID, 0.01N[1]

This is prepared and standardized according to the directions given in Chapter 5. It is used only for such cases as lactones where it is advisable to add an excess of alkali and back-titrate or if by accident the end point has been overstepped.

PHENOLPHTHALEIN INDICATOR

This is prepared according to the directions given in Chapter 5.

NEUTRAL ETHANOL, 95%

Several drops of phenolphthalein indicator are added to 200–300 ml. of 95% ethanol in a 1-liter Erlenmeyer flask. The contents of the flask are boiled for 30 seconds on a steam bath and then enough 0.1*N* or 0.01*N* sodium hydroxide is added to produce a *faint* pink coloration. The ethanol is cooled and stored in a ground-glass stoppered bottle. More 0.01*N* alkali must be added from time to time to keep it neutral. This is used only for substances which are not soluble in water.

DISTILLED WATER

After being boiled for 30 seconds, 10 ml. of this should require one drop of 0.01*N* alkali to give an end point with phenolphthalein. Otherwise, it must be neutralized as described above for ethanol.

Apparatus

MICROBURETTES[90,91,132,163]

Two microburettes of the types described in Chapter 5 are required (see Figs. 69 and 70).

*Procedure**[162,163]

Five to 10 mg., or preferably enough sample to require about 5 ml. of 0.01*N* alkali, is placed in a 125-ml. Erlenmeyer flask. If the substance is water-soluble, 10 ml. of water is added (otherwise, 10 ml. of neutral ethanol is used), warming if necessary to bring about solution. One or two drops of phenolphthalein indicator is added and the contents of the flask boiled for 30 seconds (on a steam bath, if neutral ethanol is used). The *hot* solution is then titrated with 0.01*N* sodium hydroxide to a pink end point which persists for one minute. (Note: It is good practice to heat the solution once or twice during the titration to make certain that it is carbon dioxide free.) If, by accident, the end point is overstepped, a measured amount of standard 0.01*N* hydrochloric acid is added and then standard alkali again to the proper end point. Likewise, certain samples are best handled by back-titrating. In these cases, a measured amount (excess) of standard alkali is added and then the hot solution back-titrated with standard acid to just expel the color. Enough standard alkali (one or two drops, at most, should be needed) is then added to produce a pink coloration which lasts for one minute.

Calculations:

$$\text{Neut. Equiv.} = \frac{\text{Wt. of sample in grams} \times 1000}{\text{No. ml. of } N \text{ alkali used}}$$

Since the number of grams × 1000 is equal to the number of milligrams, the formula becomes

$$\text{Neut. Equiv.} = \frac{\text{Wt. sample in mg.}}{\text{No. ml. of } N \text{ alkali used}}$$

or

$$\text{Neut. Equiv.} = \frac{\text{Wt. sample in mg.} \times 100}{\text{No. ml. of } 0.01N \text{ alkali used}}$$

Example:

4.85 ml. of 0.01*N* NaOH was required for a 6.025-mg. sample

$$\therefore \text{Neut. Equiv.} = \frac{6.025 \times 100}{4.85} = 124$$

Allowable error ±2.0%.

The results may also be calculated as per cent of carboxyl, COOH, if this group is known to be present:

Factor:

1 ml. of 0.01*N* NaOH is equivalent to 0.4502 mg. of COOH

$$\therefore \frac{\text{ml. of } 0.01N \text{ NaOH} \times 0.4502 \times 100}{\text{Wt. sample}} = \%\ \text{COOH}$$

* Compare Clark,[32] Grant,[61,62] Niederl and Niederl,[120,121] and Roth.[136-139]

Example:

Calculating the above example as COOH, instead of as Neutralization Equivalent, it becomes

$$\frac{4.85 \times 0.4502 \times 100}{6.025} = 36.2\%\ \text{COOH}$$

The results may be calculated as per cent chlorine, bromine, sulfur, etc., if these are known to be present as the hydrochloride, hydrobromide, sulfate, etc., and *carboxyl* is known to be *absent.* Obviously, the factors would then be as follows:

Factors:

1 ml. of $0.01N$ NaOH is equivalent to:

0.3546 mg. of Cl
0.7992 mg. of Br
0.1603 mg. of S
etc.

$$\therefore \frac{\text{ml. of } 0.01N \text{ NaOH} \times \text{Factor} \times 100}{\text{Wt. sample}} = \%\ \text{Element}$$

Example:

3.00 ml. of $0.01N$ NaOH was required for a 6.000-mg. sample of a hydrochloride (*no* carboxyl present)

$$\therefore \frac{3.00 \times 0.3546 \times 100}{6.000} = 17.73\%\ \text{Cl}$$

TABLE 27

ADDITIONAL INFORMATION ON REFERENCES* RELATED TO CHAPTER 15

In addition to the material presented in the preceding pages of this chapter, the author wishes to call to the attention of the reader the numerous references listed in Table 27. (See statement at top of Table 4 of Chapter 1, regarding completeness of this material.)

Books

Belcher and Godbert, 9, 10
Block and Bolling, 18
Clark, E. P., 32
Clark, S. J., 33
Clark, W. M., 34
Friedrich, 45
Fritz and Hammond, 46
Furman, 50
Grant, 61, 62
Milton and Waters, 114, 115
Niederl and Niederl, 120, 121
Pregl, 132
Roth, 136–139

Books (*Cont.*)

Siggia, 149
Steyermark, 163

Reviews

Dunn, 35
Hallett, 67
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Kirsten, 88
Lacourt, 98
Ma, 104
Mitchell, Montague, and Kinsey, 116
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* The numbers which appear after each entry in this table refer to the literature citations in the reference list at the end of the chapter.

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Submicro- ultramicro-methods

Giri, Radhakrishnan, and Vaidyana-
Bergold and Pister, 12
Bonting, 20
Gordon, 60
Grant, W. M., 64
Grunbaum, Schaffer, and Kirk, 66
Hullin and Noble, 76
Kirsten, 88
Koepsell and Sharpe, 92
Lowry, Lopez, and Bessey, 103
Mannelli, 105
Tsao, Baumann, and Wark, 175
Tsao and Brown, 176
Wellington, 187
West, 188

Direct neutralization (acidimetric methods)

Black, 15
Ellenbogen and Brand, 39
Friedrich, 45
Gorbach, 57, 58
Grassmann and Heyde, 65
Hurka, 78
Jerie, 81
Kul'berg, 97
Owens and Maute, 127
Pregl, 132
Roth, 136–139
Schmidt-Nielson, 144
Schneider and Foulke, 145
Smith, Mitchell, and Billmeyer, 155
Stetten and Grail, 161
Steyermark, 162, 163
Tous and Pizarro, 173
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Chromatographic methods

Bergmann and Segal, 11
Blackburn and Robson, 16
Block, 17
Bryant and O'Connor, 22
Cavallini and Frontali, 27
Claborn and Patterson, 31
Eastroe, 37
Federico and Ciucani, 42
Fromageot and Colas, 47

Chromatographic methods (Cont.)

Giri, Radhakrishnan, and Vaidyanathan, 54
James and Martin, 80
Jureček, Churáček, and Cervinka, 82
Klatzkin, 89
Löffler and Reichl, 102
Martin and Mittlemann, 106
McFarren and Mills, 111
Nair, 118
Nijkamp, 122, 123
Overell, 126
Pereira and Serra, 128
Pfeil and Goldbach, 130
Ramsey and Patterson, 135
Seligson and Shapiro, 146
Sjöquist, 152
Van de Kamer, Gerritsma, and Wansink, 178
Wellington, 187
Wieland and Feld, 189

Spectrophotometric, colorimetric methods

Bergold and Pister, 12
Bobtelsky and Graus, 19
Bonting, 20
Breusch and Tulus, 21
Calkins, 25
Cherkin, Wolkowitz, and Dunn, 28
Ciaranfi and Fonnesu, 29
Federico and Ciucani, 42
Fonnesu, 43
Forziati, Rowen, and Plyler, 44
Furman, Morrison, and Wagner, 51
Gey, 53
Gordon, 60
Grant, 63, 64
Herb and Riemenschneider, 71
Herrington, 72
Hill, 73
Koepsell and Sharpe, 92
McArdle, 108
McKinney and Reynolds, 112
Nekhorocheff and Wajzer, 119
Perlman, Lardy, and Johnson, 129
Pratt and Corbitt, 131
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Pucher, Sherman, and Vickery, 134

TABLE 27 (*Continued*)

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Schmall, Pifer, and Wollish, 142
Schmall, Pifer, Wollish, Duschinsky, and Gainer, 143
Sjöquist, 152
Szalkowski and Mader, 167
Taufel and Ruttloff, 169
Tsao, Baumann and Wark, 175
Tsao and Brown, 176
Wagner and Schröpl, 185
Weil-Malherbe and Bone, 186

Polarographic, conductometric, potentiometric, high-frequency, electrolytic methods

Butler and Czepiel, 24
Carson and Ko, 26
Elving and Van Atta, 40
Epstein, Sober, and Silver, 41
Furter and Gubser, 52
Grunbaum, Schaffer, and Kirk, 66
Hara and West, 69
Harlow and Wyld, 70
Hurka, 78
Ingold, 79
Karrman and Johansson, 87
Kolthoff, 93
Martin and Mittlemann, 106
Maurmeyer, Margosis, and Ma, 107
Oelsen and Graue, 124
Van Meurs and Dahmen, 179
Yakubik, Safranski, and Mitchell, 192
Yamamura, 193

Iodometric methods

Alicino, 3
Elek and Harte, 38
Hurka, 78
Kometiani and Sturua, 94
Shimosawa, 148

Oxidation methods

Buffa, 23
Linhardt and Reichold, 101
Pucher, 133
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Shimosawa, 148

Oxidation methods (*Cont.*)

Smith, 156
Weil-Malherbe and Bone, 186

Potassium hydrosulfide methods

Fuchs, 48, 49
Hunter and Edwards, 77
Tsurumi and Sasaki, 177

Manometric methods

See Chapter 18
Tracey, 174

Methods for amino acids

See Chapter 18
Baudet and Cherbuliez, 6
Bettzieche, 14
Blackburn and Robson, 16
Block and Bolling, 18
Bryant and O'Connor, 22
Cherkin, Wolkowitz, and Dunn, 28
Eastroe, 37
Fromageot and Colas, 47
Furman, Morrison, and Wagner, 51
Giri, Radhakrishnan, and Vaidyanathan, 54
Gorbach, 59
Grassmann and Heyde, 65
Kainz and Huber, 83
Kainz and Kasler, 84
Klatzkin, 89
Lacourt, Sommereyns, Francotte, and Delande, 99
Martin and Mittlemann, 106
McCaldin, 109
McFarren and Mills, 111
Merck, 113
Moubasher and Awad, 117
Pereira and Serra, 128
Pfeil and Goldbach, 130
Sjöquist, 152
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Spier and Pascher, 157
Steele, Sfortunato, and Ottolenghi, 158
Steers and Sevag, 159
Van Slyke and Dillon, 180
Van Slyke, Dillon, MacFadyen, and Hamilton, 181
Wellington, 187
Zeile and Oetzel, 194

TABLE 27 (*Continued*)

General, miscellaneous
Albrink, 2
Baker, 5
Beroza, 13
Block and Bolling, 18
Buffa, 23
Cimerman and Selzer, 30
Dyer, 36
Glagoleva-Malikova, 55
Goiffon and Couchoud, 56
Hopton, 75
Kaiser and Kagan, 85
Kometiani and Sturua, 94
Kottmeyer, 95, 96
Orekhovich and Tustanovskii, 125
Siggia and Floramo, 150
Stöhr and Scheibl, 164
Strong, Feeney, and Earle, 165
Sudo, Shimoe, and Tsujii, 166
Taufel, Pohloudek-Fabini, and Behnke, 168
Taussky, 170
Taylor, 171
Thomis and Kotionis, 172
Tous and Pizarro, 173
Volpi, 184
Wiese and Hansen, 190

Microdiffusion, microdistillation
Lang and Pfleger, 100
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Complexometric methods
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Nonaqueous titration
Maurmeyer, Margosis, and Ma, 107
Sensabaugh, Cundiff, and Markunas, 147
Van Meurs and Dahmen, 179
Yakubik, Safranski, and Mitchell, 192
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Determination of apparent dissociation constants
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Fluoro-compounds
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Apparatus
Hunter and Edwards, 77
McClendon, 110
Smith, Mitchell, and Billmeyer, 155
Stetten and Grail, 161
Sudo, Shimoe, and Tsujii, 166
Van Slyke, Folch, and Plazin, 182
Van Slyke and Neill, 183
Yakubik, Safranski, and Mitchell, 192

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