

# CONTENTS

## PART I. PHYSICAL CHEMISTRY

CHAPTER I. PROPERTIES OF DILUTE SOLUTIONS	Page
1. Copper ferrocyanide as a semipermeable membrane	3
2. Prussian blue as a semipermeable membrane	4
3. Vegetable cells as a semipermeable membrane	4
4. Cellophane as a semipermeable membrane	4
5. To determine the boiling point constant for water	5
6. To find the degree of ionisation of potassium chloride	6
7. To find the freezing point constant for water	7
8. To find the molecular weight of naphthalene (Rast)	8
CHAPTER II. REVERSIBLE REACTIONS AND THE LAW OF MASS ACTION	
9. Dependence of rate of reaction on concentration	10
10. To show the effect of alteration of concentration	11
11. To show the effect of temperature on chemical equilibrium	13
CHAPTER III. OXIDATION AND REDUCTION	
12. To show bromine water, etc., are oxidising agents	14
13. To compare potassium chlorate and potassium persulphate as oxidising agents	15
14. To show that nitrous acid may act as either an oxidising or reducing agent	15
15. To show hydrogen sulphide and sulphurous acid are reducing agents	16
CHAPTER IV. HYDROGEN ION CONCENTRATION	
16. To make solutions of pH values 3 to 11	18
17. To find the pH value of solutions of certain salts	19
CHAPTER V. THERMOCHEMISTRY	
18. To find the heat of solution of sodium thiosulphate crystals	21
19. To determine the heat of neutralisation of caustic soda by hydrochloric acid	22
CHAPTER VI. PARTITION COEFFICIENT	
20. To find the partition coefficient of succinic acid between water and ether	23
21. To find the partition coefficient of iodine between water and carbon tetrachloride	24
22. To find the partition coefficient of glacial acetic acid between water and carbon tetrachloride	25

	Page
<b>CHAPTER VII. CATALYSIS</b>	
23. To show manganese dioxide is a catalyst	27
24. Catalytic decomposition of hydrogen peroxide	27
25. Catalytic oxidation of methyl alcohol and ammonia	27
26. To show carbon monoxide will not burn in dry air	28
27. To show that dry hydrogen sulphide and dry sulphur dioxide will not react	29
28. To show bromine catalyses the oxidation of sulphur	29
29. To show brucine retards the oxidation of sulphites	29
30. Catalytic decomposition of hypochlorites	30
 <b>CHAPTER VIII. ATOMIC AND MOLECULAR WEIGHTS</b>	
31. To find the atomic weight of copper	31
32. To find the atomic weight of mercury	32
33. To find the atomic weight of potassium, silver and chlorine	32
34. To find the molecular weight of carbon dioxide	35
35. To find the vapour density of chloroform (Dumas)	36
36. To find the vapour density of ether (Victor Meyer)	37
 <b>CHAPTER IX. SOLUTIONS</b>	
37. To show the solution of bromine in air	40
38. To determine the composition of the gas boiled out of water	40
39. To determine the solubility of a very soluble gas	41
40. To effect a partial separation of water and alcohol by distillation	42
41. Preparation of a supersaturated solution	43
42. To obtain a solubility curve for phenol in water	43
43. To obtain a solubility curve for potassium chlorate	44
44. Solubility of potassium chlorate (alternative method)	45
45. Preparation of potassium perchlorate as an example of fractional crystallisation	45
 <b>CHAPTER X. THE COLLOIDAL STATE</b>	
46. The ultramicroscope—Brownian movement	47
47. To show dialysis	47
48. Preparation of a colloidal solution of antimony trisulphide	48
49. Preparation of an olive oil emulsion	49
50. Preparation of colloidal arsenious sulphide	49
51. Preparation of colloidal ferric hydroxide	49
52. Preparation of colloidal sulphur	49
53. Preparation of resin sol by dispersion	50

## PART II. INORGANIC CHEMISTRY

CHAPTER XI. GROUP I OF THE PERIODIC TABLE	Page
General	53
54. Reactions of solid copper compounds	54
55. Reactions of cupric ions	54
56. Preparation of cupric ammonium sulphate	55
57. Preparation of cuprammonium sulphate	55
58. Preparation of cuprous oxide	55
59. Preparation of cuprous chloride	56
60. Reactions of cuprous compounds	56
61. Reactions of silver compounds	57
62. Recovery of silver from silver chloride	58
CHAPTER XII. GROUP II OF THE PERIODIC TABLE	
General	59
63. Reactions of magnesium and its compounds	60
64. Reactions of calcium and its compounds	61
65. Reactions of strontium compounds	61
66. Reactions of barium compounds	62
67. Reactions of zinc and its compounds	62
68. Reactions of cadmium salts	63
69. General reaction of mercury compounds	63
70. Reactions of mercurous compounds	64
71. Reactions of mercuric compounds	64
72. To illustrate the relation between mercurous and mercuric mercury	65
73. To show the relation between the two forms of mercuric iodide	65
74. Preparation of mercuric iodide and Nessler's solution	66
CHAPTER XIII. GROUP III OF THE PERIODIC TABLE	
General	67
75. The reactions of aluminium	67
76. The reactions of aluminium salts	67
77. Oxidation of aluminium when in form of amalgam	68
78. Preparation of potash alum	69
79. Preparation of ferric ammonium alum	69
80. Preparation of chrome alum	69
CHAPTER XIV. GROUP IV OF THE PERIODIC TABLE	
General	71
81. Preparation and properties of silica and silicon	71
82. Preparation of silico-methane	72
83. Reactions of tin and its compounds	72

	Page
84. Preparation and properties of stannic chloride	73
85. Equivalent of tin by preparation of stannic oxide	74
86. Reactions of lead and its compounds	75
87. Experiments with tetravalent lead	75
 CHAPTER XV. GROUP V OF THE PERIODIC TABLE	
General	77
88. Reactions of the nitrites	78
89. Reactions of the nitrates	80
90. Reactions of the phosphites	81
91. Reactions of phosphorus and the phosphates	81
92. Preparation of phosphorus pentachloride	83
93. Action of water on the chlorides of phosphorus	84
94. Preparation of microcosmic salt	84
95. Reactions of arsenic	84
96. Reactions of arsenious compounds	85
97. Reactions of arsenic compounds	86
98. Reactions of antimony	87
99. Reactions of antimonious compounds	87
100. Reactions of antimonic compounds	88
101. Reactions of bismuth compounds	88
 CHAPTER XVI. GROUP VI OF THE PERIODIC TABLE	
General	89
102. Preparation of oxides by direct oxidation	89
103. Preparation of oxides by indirect oxidation	90
104. Preparation of hydrogen peroxide solution	90
105. Properties of hydrogen peroxide	90
106. Preparation of ozonised oxygen	91
107. Preparation of forms of sulphur	92
108. Preparation of sulphides	93
109. Preparation of chlorides and oxychlorides of sulphur	93
110. Properties of sulphur dioxide	95
111. Reactions of sodium sulphite	95
112. Preparation and properties of sodium thiosulphate crystals	96
113. Reactions of chromium compounds	97
114. Preparation of chromium trioxide	99
 CHAPTER XVII. GROUP VII OF THE PERIODIC TABLE	
General	100
115. Preparation of hydrogen fluoride and its effect on glass	101
116. Preparation of silicon tetrafluoride and to show its action on water. (Pure silica from sand.)	101
117. To compare and contrast the chloride, bromide and iodide of silver	102

## CONTENTS

xiii

	Page
118. Some reactions of chlorides	103
119. Preparation of chlorine	104
120. Preparation of anhydrous ferric chloride	105
121. Action of conc. sulphuric acid on potassium chlorate	105
122. Reactions of bromine	106
123. Reactions of bromine water	106
124. Preparation and properties of hydrogen bromide	107
125. Preparation of hydrogen bromide (demonstration)	108
126. Preparation of potassium bromide	109
127. Reactions of bromides	110
128. Class preparation of hydrogen iodide	110
129. Preparation of hydrogen iodide (demonstration)	111
130. Reactions of iodides	112
131. Preparation of iodic acid and potassium iodate	112
132. Reactions of manganous salts	113
133. Preparation and reactions of manganates	114
134. Preparation of potassium permanganate	114
135. Reactions of the permanganate ion	115
<b>CHAPTER XVIII. GROUP VIII OF THE PERIODIC TABLE</b>	
General	117
136. Revisionary experiments with ferrous and ferric salts	118
137. Conversion of ferrous salt to ferric salt and vice versa	118
138. Preparation of ferrous oxide	119
139. Preparation of ferric oxide	119
140. To show that ferroso-ferric oxide is a mixed base	120
141. Action of heat on hydrated iron chlorides	120
142. Preparation of ferrous ammonium sulphate	120
143. Properties of cobalt salts	120
144. Properties of nickel salts	121
145. To prepare sulphides of iron, cobalt and nickel	122

## PART III. ORGANIC CHEMISTRY

<b>CHAPTER XIX. INTRODUCTION TO PRACTICAL ORGANIC CHEMISTRY</b>	
General instructions	125
<b>CHAPTER XX. PURITY OF COMPOUNDS</b>	
146. To find the melting point of meta-dinitrobenzene	127
147. To find the boiling point of benzene	129
148. Separation of a mixture of ether and aniline	130

<b>CHAPTER XXI. DETECTION OF ELEMENTS IN AN ORGANIC COMPOUND</b>		<b>Page</b>
149.	Detection of carbon and hydrogen	131
150.	Detection of nitrogen	132
151.	Detection of halogens	133
152.	Detection of sulphur	134
153.	Middleton's method for detecting nitrogen, the halogens and sulphur	134
154.	Estimation of nitrogen in urea, Kjeldahl's method	135
<b>CHAPTER XXII. PROPERTIES OF ALCOHOLS</b>		
155.	Preparation of sodium ethoxide	137
156.	Determination of the equivalent of sodium	137
157.	Reaction of ethyl alcohol with hydrogen bromide	138
158.	Reaction of ethyl alcohol with acetic acid	139
159.	Oxidation of ethyl alcohol	139
160.	Distinguishing test for ethyl alcohol	140
161.	The reaction between ethyl alcohol and phosphorus pentachloride	140
<b>CHAPTER XXIII. ALKYL HALIDES</b>		
162.	Preparation of ethyl bromide	141
163.	Preparation of methyl iodide	142
164.	Reactions of alkyl halides	143
<b>CHAPTER XXIV. ETHERS</b>		
165.	Preparation of di-ethyl ether. Continuous process	145
166.	Preparation of di-ethyl ether from ethyl iodide	147
167.	Reactions of ether	147
<b>CHAPTER XXV. CHLOROFORM AND IODOFORM</b>		
168.	Preparation of chloroform	148
169.	Reactions of chloroform	149
170.	Preparation of iodoform	150
171.	Reactions of iodoform	150
<b>CHAPTER XXVI. ALDEHYDES AND KETONES</b>		
172.	Preparation of formaldehyde by oxidation with air	152
173.	Preparation of acetaldehyde	153
174.	Purification of acetaldehyde	153
175.	Preparation of acetone	155
176.	Aldehydes as reducing agents	156
177.	Preparation of an addition compound (bisulphite)	157
178.	Action of ammonia on formaldehyde	158
179.	Preparation of condensation compounds	158
180.	Preparation of polymers	159
181.	Further reactions of aldehydes and ketones	159

# CONTENTS

xv

	Page
<b>CHAPTER XXVII. ACIDS</b>	
182. Preparation of formic acid	161
183. Preparation of lead formate	162
184. Preparation of pure formic acid from lead formate	162
185. Reactions of formic acid	163
186. Reactions of acetic acid	164
 <b>CHAPTER XXVIII. ESTERS, ACYL CHLORIDES, AMIDES AND NITRILES</b>	
187. Preparation of an ester. Ethyl acetate	166
188. Hydrolysis of an ester. Saponification	167
189. Preparation of an acyl chloride. Acetyl chloride	167
190. Reactions of acetyl chloride	168
191. Preparation of an amide. Acetamide	169
192. Reactions of acetamide	170
193. Preparation of aceto-nitrile	171
 <b>CHAPTER XXIX. AMINES</b>	
194. Preparation of methylamine and its hydrochloride	173
195. Reactions of methylamine	174
 <b>CHAPTER XXX. HYDROCARBONS</b>	
196. Preparation of the paraffin, methane	177
197. Preparation of the olefine, ethylene	177
198. Preparation of ethylene dibromide	178
199. Preparation of acetylene	179
 <b>CHAPTER XXXI. AROMATIC COMPOUNDS</b>	
200. Preparation of benzene hexabromide	182
201. Preparation of mono-nitrobenzene	182
202. Preparation of bromo-benzene	184
203. Preparation of sodium salt of benzene sulphonic acid	185
204. Preparation of acetophenone	186
205. Preparation of meta-dinitrobenzene	187
206. Preparation of aniline (notes on steam distillation)	188
207. Reactions of aniline	190
208. Preparation of acetanilide	191
209. Preparation of meta-nitraniline	192
210. Preparation of phenol from aniline	193
211. Preparation of phenol from sodium benzene sulphonate	194
212. Reactions of phenol	195
213. Preparation of para-chlorotoluene (Sandmeyer)	196
214. Preparation of iodobenzene	197
215. Small scale preparation and reactions of benzene diazonium chloride	198
216. Preparation of benzyl chloride	199

	Page
217. Preparation of benzaldehyde	201
218. Reactions of benzaldehyde	202
219. Reactions of benzoic acid	203
220. Reactions of salicylic acid	204

#### PART IV. VOLUMETRIC ANALYSIS

*Note.—Further exercises and some numerical examples will be found at the end of each chapter.*

CHAPTER XXXII. INTRODUCTION	209
CHAPTER XXXIII. INDICATORS	219
CHAPTER XXXIV. ACIDIMETRY AND ALKALIMETRY	
221. To standardise a solution of hydrochloric acid	230
222. Use of borax to standardise a solution of hydrochloric acid	233
223. To standardise a solution of caustic soda by means of oxalic acid	234
224. To standardise a solution of caustic soda by means of succinic acid	235
225. Standardisation of an acid by the Iceland Spar method	236
226. To determine the equivalent of calcium carbonate by the method of back titration	236
227. To determine the number of molecules of water of crystallisation in washing soda crystals	237
228. To determine the amounts of sodium carbonate and sodium hydroxide in a mixture (double indicator)	238
229. Determination of the amounts of sodium carbonate and sodium hydroxide in a mixture (C. Winkler)	240
230. Estimation of ammonia in ammonium sulphate by the indirect method	241
231. Estimation of ammonia in an ammonium salt by the direct method	242
232. To determine the degree of temporary hardness in water	243
CHAPTER XXXV. POTASSIUM PERMANGANATE	
233. Standardisation of potassium permanganate solution by a ferrous salt	249
234. Standardisation of potassium permanganate solution by sodium oxalate	251
235. Determination of the number of molecules of water of crystallisation in a molecule of ferrous sulphate crystals	252

## CONTENTS

xvii

Page

236. Estimation of the percentage by weight of iron in iron wire 253
237. Estimation of ferric iron in ferric ammonium alum 254
238. Other methods of reducing the ferric salt. Use of zinc amalgam 256
239. Estimation of oxalic acid and one of its soluble salts in a mixture of the two 256
240. Estimation of hydrogen peroxide 258
241. Estimation of percentage purity of commercial sodium nitrite 259
242. Given that ferrous ammonium sulphate has the formula  $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ , determine  $x$  260
243. Analyse a given mixture of potassium sulphate and potassium permanganate 260
244. Determine the solubility of ammonium oxalate in water at room temperature in gm. of anhydrous salt per litre of solution 260
245. Determine accurately the equivalent weight in grams of the given organic acid 261
246. Determine the percentage of manganese dioxide in a given sample of pyrolusite 261

### CHAPTER XXXVI. POTASSIUM DICHROMATE

247. Estimation of the percentage purity of a sample of metallic tin 267
248. To determine the percentage purity of a sample of potassium chromate 269
249. To determine the percentage of potassium chlorate in a given sample 269
250. To determine the percentage of iron in a sample of iron alum, reducing the iron by stannous chloride 270
251. Determination of the percentage of iron in a sample of spathic iron ore 270

### CHAPTER XXXVII. IODINE AND SODIUM THIOSULPHATE

252. Standardisation of sodium thiosulphate solution by  $N/10.\text{KMnO}_4$  274
253. Standardisation of sodium thiosulphate solution by pure potassium iodate 274
254. To prepare a standard iodine solution 275
255. Estimation of available chlorine in bleaching powder 275
256. Estimation of copper 277
257. Estimation of a sulphite 278

	Page
<b>CHAPTER XXXVIII. SILVER NITRATE</b>	
258. Standardisation of silver nitrate solution	283
259. Standardisation of hydrochloric acid by silver nitrate	284
260. Determination of amounts of sodium and potassium chloride in a mixture	285
261. To determine the number of molecules of water of crystallisation in barium chloride crystals	286
262. Estimation of chloride and alkali in a solution containing them both	288
263. Alternative method for Expt. 262	288
264. Estimation of chloride and acid in a solution containing both	289
265. Estimation of percentage of potassium chlorate in a mixture of potassium chlorate and potassium sulphate	289
<b>CHAPTER XXXIX. POTASSIUM THIOCYANATE</b>	
266. Standardisation of potassium thiocyanate solution	292
267. Estimation of purity of sodium chloride	293
268. To determine the percentage of silver in an alloy	294
<b>CHAPTER XL. ADSORPTION INDICATORS</b>	
269. To standardise a solution of hydrochloric acid using fluorescein	298
270. To find the equivalent weight of potassium bromide	299
271. To estimate the purity of lead nitrate crystals by titration against sodium hydroxide	300
272. To determine the strength of a potassium thiocyanate solution	300
<i>Answers to questions and calculations</i>	301
 <b>PART V. A SYSTEM OF QUALITATIVE ANALYSIS</b>  	
<b>CHAPTER XLI. PRELIMINARY TESTS AND MAKING A SOLUTION</b>	<b>305</b>
<b>CHAPTER XLII. TESTS FOR ACID RADICALS IN SOLUTION</b>	<b>309</b>
<b>CHAPTER XLIII. EXAMINATION FOR METALLIC RADICALS</b>	
273. Preliminary experiments to use of Group I	314
Separation into groups	316
<b>CHAPTER XLIV. GROUP ANALYSIS AND THE IONIC THEORY</b>	<b>329</b>
<b>CHAPTER XLV. ORGANIC REAGENTS IN ANALYSIS</b>	
General	336
Table of confirmatory tests for metals in order of groups	337

## PART VI. GRAVIMETRIC ANALYSIS

	Page
CHAPTER XLVI. GENERAL REMARKS ON TECHNIQUE	345
CHAPTER XLVII. ESTIMATION OF IRON, ALUMINIUM, SULPHATE RADICAL, MAGNESIUM, CALCIUM AND TIN	
274. Estimation of iron in ferrous ammonium sulphate	348
275. Estimation of aluminium in aluminium sulphate	348
276. Estimation of sulphate radical in sodium sulphate	349
277. Estimation of magnesium in magnesium sulphate	349
278. Estimation of calcium in calcium carbonate	350
279. Estimation of tin in solder	351

## PART VII. ELEMENTARY BIOCHEMISTRY

CHAPTER XLVIII. CARBOHYDRATES	
280. Reactions of simple sugars	355
281. Distinguishing test for fructose	357
282. Estimation of a reducing sugar with Benedict's solution	357
283. Hydrolysis of cane-sugar. Preparation of glucose	358
284. Reactions of cane-sugar	358
285. Oxidation of cane-sugar. Preparation of oxalic acid	358
286. Reactions of oxalic acid	359
287. Hydrolysis of starch by acids	360
288. Hydrolysis of starch in stages	360
289. Hydrolysis of starch by ptyalin	360
290. Reactions of cellulose	361
CHAPTER XLIX. FATS	
291. To find the acid value of a fat	362
292. Comparison of unsaturation of fats	362
293. Saponification of a fat	363
294. Reactions of soap	363
CHAPTER L. PROTEINS	
295. Tests for proteins	365
296. Amphoteric nature of a protein	366
297. Reactions of urea	367
CHAPTER LI. VITAMINS	
298. Test for vitamin A	368
299. Test for vitamin C	368
300. Estimation of vitamin C	368

## APPENDICES

	Page
I. TABLE OF APPARATUS AND MATERIALS	370
II. MOLECULAR DEPRESSION OF THE FREEZING POINT CONSTANTS	371
III. MOLECULAR ELEVATION OF THE BOILING POINT CONSTANTS	371
IV. DISSOCIATION CONSTANTS OF ACIDS	371
V. DISSOCIATION CONSTANTS OF BASES	371
VI. PHYSICAL CONSTANTS OF SUBSTANCES	372
VII. PHYSICAL CONSTANTS OF ORGANIC COMPOUNDS	374
VIII. TABLE OF ATOMIC WEIGHTS	376
IX. TABLE OF APPROXIMATE ATOMIC WEIGHTS	377
X. MAXIMUM PRESSURE OF AQUEOUS VAPOUR	377
XI. LOGARITHMS	378

## INDEX