

LABORATORY MANUAL
IN
GENERAL SCIENCE

CLARK

LABORATORY MANUAL

IN

GENERAL SCIENCE

BY

BERTHA M. CLARK, PH.D.

HEAD OF THE SCIENCE DEPARTMENT

WILLIAM PENN HIGH SCHOOL FOR GIRLS, PHILADELPHIA



NEW YORK ··· CINCINNATI ··· CHICAGO

AMERICAN BOOK COMPANY

COPYRIGHT, 1912, BY
BERTHA M. CLARK.

ENTERED AT STATIONERS' HALL, LONDON

CLARK'S LABORATORY MANUAL.

W. P. 3

CONTENTS

HEAT

EXPERIMENT	PAGE
1. THE THERMOMETER	9
2. TEMPERATURE CURVES	10
3. COEFFICIENT OF EXPANSION OF A SOLID	12
4. CONVECTION OF HEAT	14
5. FALL OF TEMPERATURE	15
6. VENTILATION	16
7. LAW OF MIXTURES	16

SPECIFIC HEAT, ETC.

8. DETERMINATION OF THE SPECIFIC HEAT OF LEAD	19
9. BOILING POINTS	20
10. MELTING POINTS	20
11. GLASS MOLDING	21
12. THE HEAT LATENT IN ICE; OR THE ABSORPTION OF HEAT BY MELTING	23
13. THE COOLING EFFECT OF EVAPORATION	24
14. CONDENSATION	24
15. SOLUTIONS	26
16. NEED OF OXYGEN FOR COMBUSTION	26
17. TO MAKE CARBON DIOXIDE	28
18. TESTING FOR CARBON DIOXIDE	28
19. DISTILLATION OF COAL AND WOOD	29

FOODS

EXPERIMENT	PAGE
20. THE PRESENCE OF STARCH IN SOME COMMON FOODS .	31
21. THE PRESENCE OF FATS IN SOME COMMON FOODS .	32
22. AN ARTIFICIAL EMULSION	33
23. A NATURAL EMULSION	34
24. PROTEIDS IN SOME COMMON FOODS	35
25. EFFECT OF HEAT ON PROTEIDS	36
26. THE PRESENCE OF WATER IN SOME COMMON FOODS .	36

WATER

27. PRECIPITATION AND FILTRATION	37
28. SOLVENT ACTION OF WATER	38
29. ORGANIC MATTER IN WATER	39
30. FILTRATION	39
31. DISTILLATION	40
32. TO TEST THE PURITY OF YOUR HOME DRINKING WATER	40

PRESSURE

33. TO MEASURE THE WATER AND GAS PRESSURE IN THE LABORATORY TABLES	42
34. TO FIND THE COST PER HOUR OF A SINGLE GAS BURNER IN YOUR HOME	43
35. TO FIND HOW MUCH GAS YOUR HOME USES IN A WEEK OR MONTH	45
36. BOYLE'S LAW	45
37. ISOTHERMAL LINES	47
38. BAROMETRIC CURVE	47
39. HEAT OF COMPRESSION	50
40. COLD OF EXPANSION	50

LIGHT

EXPERIMENT	PAGE
41. RELATIVE VALUE OF DIFFERENT LIGHTS	52
42. REFLECTION—HOW LIGHT IS REFLECTED	53
43. THE PATH OF LIGHT THROUGH PLATE GLASS	55
44. THE PATH OF LIGHT THROUGH A GLASS PRISM	56
45. APPARENT DEPTH OF A POND	56
46. PHOTOGRAPHIC PAPER	58
47. LENSES	58
48. THE MAGNIFYING POWER OF A SIMPLE LENS	60
49. A TEST FOR SIGHT	61
50. LIGHT AND ITS EFFECT ON MICROÖRGANISMS	61
51. THE CHEMICAL ACTION OF LIGHT	62
52. ILLUMINATION AND COLOR	62
53. HOW STRANGE COLORS ARE PRODUCED	63
54. HEATING POWER OF DIFFERENT COLORS	64

MACHINES

55. THE LEVER	65
56. THE INCLINED PLANE	66
57. PULLEYS	67
58. THE POWER OF STEAM	68

CHEMISTRY

59, 60. THE CHARACTERISTICS OF ACIDS AND OF BASES . .	69
61. NEUTRALIZATION	70
62. TO MAKE SOAP	71
63. HARD WATER—SOAP	71
64, 65. BAKING SODA	72
66. BLEACHING POWDERS	73
67. THE REMOVAL OF STAINS	74

EXPERIMENT	PAGE
68. DIRECT DYEING	74
69. INDIRECT DYEING. MORDANTING	75
70. TO DETECT THE PRESENCE OF FAT AND OIL IN FOODS .	76
71. TO DETECT ARTIFICIAL COLORING MATTER IN FOODS .	76
72. TO DETECT ARTIFICIAL COLORING MATTER IN FOODS .	77
73. TO DETECT ALUM IN BAKING POWDER	78
74. TO DETECT FORMALDEHYDE IN MILK	78
75. TO DETECT GELATIN IN MILK AND ICE CREAM . . .	78
76. TO DETECT BORIC ACID AND SULPHIDES IN MEAT . .	79
77. TO DETECT COTTONSEED OIL	79
78. CHEMICALS AS PRESERVATIVES	80
79. THE EFFECT OF HEAT ON BACTERIA	81

SOUND

80. SOUND DUE TO VIBRATION	82
81. THE REFLECTION OF SOUND	83
82. RESONANCE	84
83. A TEST FOR HEARING	84

ELECTRICITY

84. SOME EFFECTS OF ELECTRICITY	86
85. ELECTRICITY AS A SOURCE OF HEAT	88
86. ELECTRICITY AS A MAGNET	89
87. THE ELECTRIC BELL	90
88. MAGNETS AND THEIR ACTION ON IRON FILINGS . .	91
89. THE ACTION OF MAGNETS ON EACH OTHER . . .	92
90. OTHER RESPECTS IN WHICH AN ELECTRIC CURRENT IS LIKE A MAGNET	93
91. THE PRINCIPLE OF THE MOTOR	94
92. THE PRINCIPLE OF THE DYNAMO AND THE TELEPHONE .	95

LABORATORY MANUAL

IN

GENERAL SCIENCE

BY

BERTHA M. CLARK, PH.D.

HEAD OF THE SCIENCE DEPARTMENT

WILLIAM PENN HIGH SCHOOL FOR GIRLS, PHILADELPHIA



NEW YORK ··· CINCINNATI ··· CHICAGO

AMERICAN BOOK COMPANY

COPYRIGHT, 1912, BY
BERTHA M. CLARK.

ENTERED AT STATIONERS' HALL, LONDON

CLARK'S LABORATORY MANUAL,

W. P. 3

PREFACE

THIS *Laboratory Manual* is designed to accompany my *General Science*. The experiments contained in the manual, with the exception of those on Specific Heat, Heats of Fusion and Vaporization, and a few others, can be easily and intelligently made by the average pupil, since little or no mathematics is involved.

The elaborate and quantitative experiments required for college preparation have been entirely omitted. Only such experiments are given as will prove of interest and benefit to the pupils whose formal education ends with the high school.

It is my experience that five periods per week for one year will suffice to cover the ground indicated in *General Science* and most of the ground indicated in the *Laboratory Manual*. If there is not time to make all the experiments, Experiments 8 and 14 and others of similar detail may be omitted.

It is hoped that the heterogeneous nature of the experiments will offer something of interest and help to every pupil, and, in addition, will induce some few to take up a study of theoretical science, whether in physics or chemistry.

The metric and English systems of measurement are used indiscriminately according to convenience. The student should keep in mind that one cubic centimeter of water weighs one gram; and that an ordinary test tube

(6 inches by $\frac{3}{4}$ of an inch) contains about thirty cubic centimeters. Where only a few centimeters of a solution are to be used the liquid can be measured easily in fine burettes, and burettes of varying size should be at the disposal of each pupil.

It is desirable that *General Science* be used in connection with the *Laboratory Manual*, since the latter is not comprehensive enough to be used alone.

I take this opportunity to acknowledge my indebtedness to the following teachers of the science department: Misses Norment, Price, and Waldie, who have aided me greatly in the *General Science* and the *Manual*.

BERTHA M. CLARK.

WILLIAM PENN HIGH SCHOOL.

CONTENTS

HEAT

EXPERIMENT	PAGE
1. THE THERMOMETER	9
2. TEMPERATURE CURVES	10
3. COEFFICIENT OF EXPANSION OF A SOLID	12
4. CONVECTION OF HEAT	14
5. FALL OF TEMPERATURE	15
6. VENTILATION	16
7. LAW OF MIXTURES	16

SPECIFIC HEAT, ETC.

8. DETERMINATION OF THE SPECIFIC HEAT OF LEAD	19
9. BOILING POINTS	20
10. MELTING POINTS	20
11. GLASS MOLDING	21
12. THE HEAT LATENT IN ICE; OR THE ABSORPTION OF HEAT BY MELTING	23
13. THE COOLING EFFECT OF EVAPORATION	24
14. CONDENSATION	24
15. SOLUTIONS	26
16. NEED OF OXYGEN FOR COMBUSTION	26
17. TO MAKE CARBON DIOXIDE	28
18. TESTING FOR CARBON DIOXIDE	28
19. DISTILLATION OF COAL AND WOOD	29

FOODS

EXPERIMENT	PAGE
20. THE PRESENCE OF STARCH IN SOME COMMON FOODS .	31
21. THE PRESENCE OF FATS IN SOME COMMON FOODS .	32
22. AN ARTIFICIAL EMULSION	33
23. A NATURAL EMULSION	34
24. PROTEIDS IN SOME COMMON FOODS	35
25. EFFECT OF HEAT ON PROTEIDS	36
26. THE PRESENCE OF WATER IN SOME COMMON FOODS .	36

WATER

27. PRECIPITATION AND FILTRATION	37
28. SOLVENT ACTION OF WATER	38
29. ORGANIC MATTER IN WATER	39
30. FILTRATION	39
31. DISTILLATION	40
32. TO TEST THE PURITY OF YOUR HOME DRINKING WATER	40

PRESSURE

33. TO MEASURE THE WATER AND GAS PRESSURE IN THE LABORATORY TABLES	42
34. TO FIND THE COST PER HOUR OF A SINGLE GAS BURNER IN YOUR HOME	43
35. TO FIND HOW MUCH GAS YOUR HOME USES IN A WEEK OR MONTH	45
36. BOYLE'S LAW	45
37. ISOTHERMAL LINES	47
38. BAROMETRIC CURVE	47
39. HEAT OF COMPRESSION	50
40. COLD OF EXPANSION	50

LIGHT

EXPERIMENT	PAGE
41. RELATIVE VALUE OF DIFFERENT LIGHTS	52
42. REFLECTION—HOW LIGHT IS REFLECTED	53
43. THE PATH OF LIGHT THROUGH PLATE GLASS	55
44. THE PATH OF LIGHT THROUGH A GLASS PRISM	56
45. APPARENT DEPTH OF A POND	56
46. PHOTOGRAPHIC PAPER	58
47. LENSES	58
48. THE MAGNIFYING POWER OF A SIMPLE LENS	60
49. A TEST FOR SIGHT	61
50. LIGHT AND ITS EFFECT ON MICROÖRGANISMS	61
51. THE CHEMICAL ACTION OF LIGHT	62
52. ILLUMINATION AND COLOR	62
53. HOW STRANGE COLORS ARE PRODUCED	63
54. HEATING POWER OF DIFFERENT COLORS	64

MACHINES

55. THE LEVER	65
56. THE INCLINED PLANE	66
57. PULLEYS	67
58. THE POWER OF STEAM	68

CHEMISTRY

59, 60. THE CHARACTERISTICS OF ACIDS AND OF BASES . .	69
61. NEUTRALIZATION	70
62. TO MAKE SOAP	71
63. HARD WATER—SOAP	71
64, 65. BAKING SODA	72
66. BLEACHING POWDERS	73
67. THE REMOVAL OF STAINS	74

EXPERIMENT	PAGE
68. DIRECT DYEING	74
69. INDIRECT DYEING. MORDANTING	75
70. TO DETECT THE PRESENCE OF FAT AND OIL IN FOODS .	76
71. TO DETECT ARTIFICIAL COLORING MATTER IN FOODS .	76
72. TO DETECT ARTIFICIAL COLORING MATTER IN FOODS .	77
73. TO DETECT ALUM IN BAKING POWDER	78
74. TO DETECT FORMALDEHYDE IN MILK	78
75. TO DETECT GELATIN IN MILK AND ICE CREAM . . .	78
76. TO DETECT BORIC ACID AND SULPHIDES IN MEAT . .	79
77. TO DETECT COTTONSEED OIL	79
78. CHEMICALS AS PRESERVATIVES	80
79. THE EFFECT OF HEAT ON BACTERIA	81

SOUND

80. SOUND DUE TO VIBRATION	82
81. THE REFLECTION OF SOUND	83
82. RESONANCE	84
83. A TEST FOR HEARING	84

ELECTRICITY

84. SOME EFFECTS OF ELECTRICITY	86
85. ELECTRICITY AS A SOURCE OF HEAT	88
86. ELECTRICITY AS A MAGNET	89
87. THE ELECTRIC BELL	90
88. MAGNETS AND THEIR ACTION ON IRON FILINGS . . .	91
89. THE ACTION OF MAGNETS ON EACH OTHER	92
90. OTHER RESPECTS IN WHICH AN ELECTRIC CURRENT IS LIKE A MAGNET	93
91. THE PRINCIPLE OF THE MOTOR	94
92. THE PRINCIPLE OF THE DYNAMO AND THE TELEPHONE .	95

LABORATORY MANUAL

HEAT

EXPERIMENT 1. THE THERMOMETER

FILL a glass tube shaped as in Figure 1 to the point *A* with mercury, and place the bulb of the tube in a beaker of boiling water which is supported on a tripod over a Bunsen flame (Fig. 2). Hold the bulb in the water for three or four minutes, and watch the mercury carefully, noting whether it rises or falls in the tube or remains stationary. At the end of several minutes note the position of the top of the mercury and mark the position on the tube by means of an ink spot.

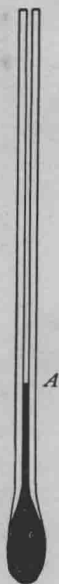


FIG. 1.—
Making a
thermom-
eter.

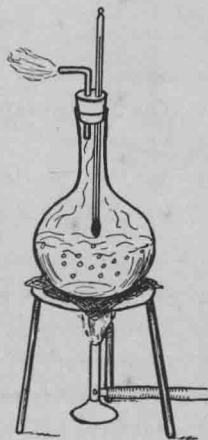


FIG. 2. — Determining
the upper point on a
thermometer.

Remove the bulb of mercury from the boiling water, and after allowing it to cool for a few minutes, put it into a beaker of chopped ice (Fig. 3); again watch the mercury in the tube, noting whether it rises or falls. At the end of several minutes note the position of the top of the mer-

cury, and mark this position also by means of an ink spot.

These two points are called the boiling point and the freezing point of water, and the distance between them is divided into equal parts called degrees. On the Fahrenheit scale it is divided into 180 degrees, and on the Centigrade into 100 degrees. The lower point on the Fahrenheit scale is marked 32° , and on the Centigrade 0° ; while the higher point on the Fahrenheit scale is marked 212° , and on the Centigrade 100° .

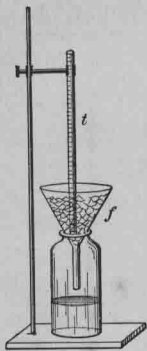


FIG. 3. — Determining the lower point on a thermometer.

A bulb of this sort filled with mercury and graduated so that unknown temperatures may be determined is called a thermometer. The Fahrenheit thermometer is used in the United States; the Centigrade is used throughout most of Europe and for all scientific purposes.

EXPERIMENT 2. TEMPERATURE CURVES

Draw two straight lines OX and OY on a piece of coördinate paper, and represent temperatures by distances above OX , and time intervals by distances to the right of OY . Let one space above OX represent one degree of temperature, and one space to the right of OY one five-minute interval. Any point on AB will represent a temperature of 12° , since it is twelve spaces above OX , and any point CD will represent a time interval of forty minutes, since it is eight spaces to the right of OY . The point at the intersection of these two lines, therefore, represents a temperature of 12° , forty minutes after