

**CHEMICAL EXPERIMENTS,  
GENERAL AND ANALYTICAL:  
FOR USE WITH ANY TEXT-BOOK  
OF CHEMISTRY, OR WITHOUT A  
TEXT-BOOK**

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Chemical Experiments, General and Analytical: For Use with Any Text-Book of Chemistry, or Without a Text-Book by R. P. Williams

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**R. P. WILLIAMS**

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# CHEMICAL EXPERIMENTS

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*R. P. Williams*

BY  
**R. P. WILLIAMS**

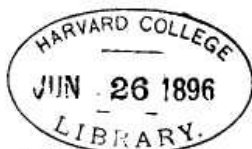
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Prof. C. E. Norton

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## PREFACE.

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THE rapid growth of the laboratory method of teaching chemistry since the author's *Manual* was issued in 1888 has called for a larger and more comprehensive work of a similar sort for high schools, academies, and colleges. To such a call the present book is a response.

In preparing the experiments the author has endeavored, *first*, to select such as are most instructive and best illustrate the subject without being too elaborate; *second*, to arrange them in an order calculated to lead up by the most natural and easiest steps to a knowledge of the science; *third*, to make the subject fascinating by giving just enough information and suggestion to interest the experimenter, and to make him work for the knowledge to be gained. Finally, the author has aimed to make the book simple enough for the dull and slow pupil, and — by the introduction of supplementary and original work — elaborate enough for the most acute. Great care has been taken to give minute and accurate directions for performing the experiments. "Terms" at the end of experiments are for pupils to study outside the laboratory, and are often repeated. They may also be discussed in the laboratory.

Metal analysis has received a somewhat unique treatment. Each metal of a group is first taken separately, and the *analytical* reactions are given. This method shows the pupil at once why a given re-agent is added, and what its effect is. The product is given when the substance is in solution as well as when it is precipitated. The group is next treated in the same way. This method clarifies the subject greatly in the pupil's mind, and is believed to be a valuable departure in teaching analysis.

The new orthography recommended by the Chemical Section of the A. A. A. S. has been adopted, as a step towards uniformity and progress.

It is recommended that wherever it is possible each laboratory period cover the space of two hours (even if there can be only one period per week), and that the last 20 or 30 minutes be taken to question the class rapidly on the work of the day, discuss and explain the use of terms, etc. The books should be inspected after each exercise, or perhaps after each experiment has been written out.

It is by no means necessary to perform every experiment, or to follow the order here given, if the teacher prefers to do otherwise. A diversity of opinion exists among teachers, and a diversity of time and talent among pupils and classes. In no place better than in the laboratory, under a competent instructor, can a "cast-iron rule" be done away with, and variety of arrangement and method be adopted.

The author would be glad to receive criticisms, as well as suggestions as to other methods, or experiments, or different ways of performing experiments. Especially would he be glad to know what it has been difficult, in the matter of directions or principles, for pupils to understand.

The author desires to acknowledge valuable suggestions in the preparation of this work from the following persons: Messrs. J. Y. Bergen, Jr., C. W. Gerould, E. F. Holden, A. S. Perkins, N. S. French, H. I. Lord, E. S. Chapin; and Misses D. M. Stickney, M. L. Foster, and others.

CAMBRIDGE,  
December 1, 1896.



## INDIVIDUAL APPARATUS.

Each pupil should be provided with the apparatus given below, but in cases where great economy must be exercised different pupils may, by working at different times, use the same set. The author has selected apparatus specially adapted, as to exact dimensions, quality, and cheapness, for performing in the best way the experiments herein described, and sets or separate pieces of this, together with other apparatus and chemicals, can be had of the L. E. Knott Apparatus Co., 14 Ashburton Place, Boston, to which firm teachers are referred for catalogs.

4 re-agent bottles, 250 cc. glass stoppers, blown labels: $\text{NH}_4\text{OH}$ , $\text{HCl}$ , $\text{HNO}_3$ , $\text{H}_2\text{SO}_4$ .	1 camel's-hair brush.
1 pneumatic trough.	1 magnet.
1 Hessian crucible.	4 wide-mouthed bottles.
2 beakers.	1 2-holed rubber stopper to fit above.
2 pieces wire gauze.	4 pieces window-glass.
1 piece platinum wire.	1 glass funnel.
1 mouth blowpipe.	1 porcelain evap. dish.
6 pieces glass tubing.	1 asbestos board.
4 pieces hard glass tubing.	1 sand bath.
1 test-tube brush.	1 pair iron forceps.
1 small tube brush.	1 triangular file.
1 doz. test tubes.	1 round file.
4 cork stoppers, for tubes.	1 piece copper wire.
1 fish-tail attachment for Bunsen burner.	1 piece lead wire.
1 blowpipe attachment with rest for Bunsen burner.	1 piece zinc wire.
1 piece sheet copper.	1 wooden test-tube holder.
1 glass retort.	1 wire test-tube rack.
1 tumbler.	1 thistle tube.
1 piece cobalt glass.	1 Bohemian flask.
1 horn spatula.	1 2-holed rubber stopper to fit flask.
1 sheet litmus paper.	1 Bunsen burner.
200 filter papers.	1 iron ring stand.
1 bunch splints.	2 ft. rubber tubing.
1 sheet turmeric paper.	1 ft. " "
	1 metric ruler.
	1 graduate.
	1 small leaden dish.

## GENERAL APPARATUS.

The requirements of general apparatus for a laboratory are too numerous and varied to be given here. A few of the pieces in more general demand for experiments in this book are as follows:

Glass-stoppered bottles.	Filter-stands.
Graduates.	Glass and rubber tubing.
Funnels.	Steel glass-cutters.
Fruit jars (for making solutions).	Steel wire-cutters.
Scales, with metric weights.	Mortars and pestles.
Ignition tubes.	Flasks.
Beakers.	Filter papers, etc., etc.

## CHEMICALS.

ESTIMATE FOR A CLASS OF TWENTY IN GENERAL CHEMISTRY AND ANALYTICAL REACTIONS, NOT INCLUDING GENERAL REACTIONS AND SUPPLEMENTARY WORK.

Acid, acetic, $\text{HC}_2\text{H}_3\text{O}_2$ ..... 4 lb.	Arsenopyrite, $\text{FeAsS}$ ..... $\frac{1}{2}$ lb.
“ boric, $\text{H}_3\text{BO}_3$ ..... $\frac{1}{2}$ “	Barium chlorid, $\text{BaCl}_2$ ..... $\frac{1}{2}$ “
“ hydrochloric, $\text{HCl}$ .....25 “	“ hydroxid, $\text{Ba}(\text{OH})_2$ ..... $\frac{1}{2}$ “
“ hydrofluoric, $\text{HF}$ ..... $\frac{1}{2}$ “	Bismuth oxychlorid, $\text{BiOCl}$ ..... $\frac{1}{2}$ “
“ hydrofluosillicic, $\text{H}_2\text{SiF}_6$ ..... $\frac{1}{2}$ “	Calcium chlorid, $\text{CaCl}_2$ ..... $\frac{1}{2}$ “
“ nitric, $\text{HNO}_3$ .....12 “	“ fluorid, powdered, $\text{CaF}_2$ ..... $\frac{1}{2}$ “
“ oxalic, $\text{H}_2\text{C}_2\text{O}_4$ ..... $\frac{1}{2}$ “	“ hypochlorite, $\text{CaCl}_2\text{O}$ ..... $\frac{1}{2}$ “
“ phosphoric, $\text{H}_3\text{PO}_4$ ..... $\frac{1}{2}$ “	“ sulfate, $\text{CaSO}_4$ ..... $\frac{1}{2}$ “
“ sulfuric, $\text{H}_2\text{SO}_4$ .....18 “	“ oxid, $\text{CaO}$ .....2 “
“ tartaric, $\text{H}_2\text{C}_4\text{H}_4\text{O}_4$ ..... $\frac{1}{2}$ “	Carbon bisulfid, $\text{CS}_2$ ..... $\frac{1}{2}$ “
Alcohol, $\text{C}_2\text{H}_5\text{OH}$ ..... 1 qt.	Charcoal, animal, gran., C..... 1 “
Alum, $\text{K}_2\text{Al}_2(\text{SO}_4)_4$ ..... 1 lb.	“ “ powdered, C..... $\frac{1}{2}$ “
Aluminum chlorid, $\text{AlCl}_3$ ..... $\frac{1}{2}$ “	“ wood, “ C..... 1 “
Ammonium carbon., $(\text{NH}_4)_2\text{CO}_3$ 1 “	“ “ C.....20 pieces
“ chlorid, $\text{NH}_4\text{Cl}$ ..... 2 “	Cobalt chlorid, $\text{CoCl}_2$ ..... $\frac{1}{2}$ lb.
“ hydroxid, $\text{NH}_4\text{OH}$ .20 “	“ nitrate, $\text{Co}(\text{NO}_3)_2$ ..... $\frac{1}{2}$ “
“ nitrate, $\text{NH}_4\text{NO}_3$ ..... 1 “	Cochineal..... $\frac{1}{2}$ “
“ oxalate, $(\text{NH}_4)_2\text{C}_2\text{O}_4$ $\frac{1}{2}$ “	Copper, turnings, Cu..... 3 “
“ sulfate, $(\text{NH}_4)_2\text{SO}_4$ ..... $\frac{1}{2}$ “	“ sheet, Cu..... $\frac{1}{2}$ “
Antimony cryst., Sb..... $\frac{1}{2}$ “	“ chlorid, $\text{CuCl}_2$ ..... 1 “
“ chlorid, $\text{SbCl}_3$ ..... $\frac{1}{2}$ “	“ nitrate, $\text{Cu}(\text{NO}_3)_2$ ..... $\frac{1}{2}$ “
Arsenious oxid, $\text{As}_2\text{O}_3$ ..... 1 oz.	“ oxid, $\text{CuO}$ ..... 1 “

Copper sulfate, $\text{CuSO}_4$ .....	$\frac{1}{2}$ lb.	Potassium, dichromate, $\text{K}_2\text{Cr}_2\text{O}_7$	1 lb.
Ether, $(\text{C}_2\text{H}_5)_2\text{O}$ .....	$\frac{1}{2}$ "	" ferrocyan., $\text{K}_2\text{Fe}(\text{CN})_2$	1 "
Gold leaf, Au.....	1 bk.	" ferricyan., $\text{K}_3\text{Fe}(\text{CN})_6$	$\frac{1}{2}$ "
Indigo.....	$\frac{1}{2}$ lb.	" iodid, KI.....	1 "
Iodin, I.....	2 oz.	" hydroxid, KOH.....	1 "
Iron, fine turnings, Fe.....	1 lb.	" nitrate, $\text{KNO}_3$ .....	1 "
" by hydrogen, Fe.....	$\frac{1}{2}$ "	" nitrite, $\text{KNO}_2$ .....	$\frac{1}{2}$ "
" perchlorid, $\text{FeCl}_4$ .....	1 "	" permangan., $\text{KMnO}_4$	$\frac{1}{2}$ "
" protosulfid, $\text{FeS}$ .....	5 "	" sulfocyanid, $\text{KSCN}$ .....	$\frac{1}{2}$ "
" pyrite, $\text{FeS}_2$ .....	$\frac{1}{2}$ "	" tartrate, $\text{K}_2\text{C}_4\text{H}_4\text{O}_6$ .....	$\frac{1}{2}$ "
" sulfate, $\text{FeSO}_4$ .....	1 "	Silica, powdered, $\text{SiO}_2$ .....	$\frac{1}{2}$ "
Lead, sheet, Pb.....	1 "	Silver nitrate, $\text{AgNO}_3$ .....	4 oz.
" wire, $\frac{1}{2}$ in. diam., Pb.....	12 ft.	Sodium, metallic, Na.....	$\frac{1}{2}$ "
" acetate, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ .....	$\frac{1}{2}$ lb.	" acetate, $\text{NaC}_2\text{H}_3\text{O}_2$ .....	$\frac{1}{2}$ lb.
" chlorid, $\text{PbCl}_2$ .....	$\frac{1}{2}$ "	" arsenite, $\text{HNa}_2\text{AsO}_3$ .....	$\frac{1}{2}$ "
" nitrate, $\text{Pb}(\text{NO}_3)_2$ .....	2 "	" bicarbonate, $\text{HNaCO}_3$ .....	$\frac{1}{2}$ "
" protoxid, $\text{PbO}$ .....	$\frac{1}{2}$ "	" bisulfate, $\text{HNaSO}_4$ .....	$\frac{1}{2}$ "
" tetroxid (red), $\text{Pb}_3\text{O}_4$ .....	$\frac{1}{2}$ "	" borate, $\text{Na}_2\text{B}_4\text{O}_7$ .....	$\frac{1}{2}$ "
Litmus, cubes.....	1 oz.	" carbonate, $\text{Na}_2\text{CO}_3$ .....	3 "
Marble chips, $\text{CaCO}_3$ .....	3 lb.	" chlorid, NaCl.....	4 "
Magnesium ribbon, Mg.....	10 ft.	" hydroxid (caust.), NaOH	3 "
" chlorid, $\text{MgCl}_2$ .....	$\frac{1}{2}$ lb.	" nitrate, $\text{NaNO}_3$ .....	2 "
" sulfate, $\text{MgSO}_4$ .....	$\frac{1}{2}$ "	" nitrite, $\text{NaNO}_2$ .....	$\frac{1}{2}$ "
Manganese chlorid, $\text{MnCl}_2$ .....	$\frac{1}{2}$ "	" oxalate, $\text{Na}_2\text{C}_2\text{O}_4$ .....	$\frac{1}{2}$ "
" dioxide, gran., $\text{MnO}_2$ .....	$\frac{1}{2}$ "	" phosphate, $\text{HNa}_2\text{PO}_4$ .....	1 "
" " powd., $\text{MnO}_2$	$1\frac{1}{2}$ "	" sulfate, $\text{Na}_2\text{SO}_4$ .....	1 "
Mercury, Hg.....	$\frac{1}{2}$ "	" sulfid, $\text{Na}_2\text{S}$ .....	$\frac{1}{2}$ "
" bichlorid, $\text{HgCl}_2$ .....	$\frac{1}{2}$ "	" sulfite, $\text{Na}_2\text{SO}_3$ .....	$\frac{1}{2}$ "
" protochlorid, $\text{Hg}_2\text{Cl}_2$ .....	$\frac{1}{2}$ "	" thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$ .....	1 "
" pernitrate, $\text{Hg}(\text{NO}_3)_2$ .....	$\frac{1}{2}$ "	Starch, $\text{C}_6\text{H}_{10}\text{O}_5$ .....	$\frac{1}{2}$ "
" protonitrate, $\text{HgNO}_3$ .....	$\frac{1}{2}$ "	Strontium chlorid, $\text{SrCl}_2$ .....	$\frac{1}{2}$ "
" oxid, $\text{HgO}$ .....	1 "	Sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ .....	1 "
Nessler's sol.....	$\frac{1}{2}$ "	Sulfur, brimstone, S.....	2 "
Phosphorus, P.....	2 oz.	" flowers, S.....	1 "
Picture wire.....	1 roll	Tin bichlorid, $\text{SnCl}_2$ .....	$\frac{1}{2}$ "
Platinum chlorid, sol., $\text{PtCl}_4$ .....	1 oz.	Turmeric paper.....	1 sheet
Potassium, metallic, K.....	$\frac{1}{2}$ "	Turpentine, $\text{C}_{10}\text{H}_{18}$ .....	1 oz.
" bromid, KBr.....	$\frac{1}{2}$ lb.	Zinc, gran., Zn.....	3 lb.
" carbonate, $\text{K}_2\text{CO}_3$ .....	$1\frac{1}{2}$ "	" wire, $\frac{1}{2}$ in. diam.....	12 ft.
" chlorid, KI.....	$\frac{1}{2}$ "	" (arsenic-free).....	1 lb.
" chlorate, $\text{KClO}_3$ .....	2 "	" chlorid, $\text{ZnCl}_2$ .....	$\frac{1}{2}$ "
" chromate, $\text{K}_2\text{CrO}_4$ .....	$\frac{1}{2}$ "	" nitrate, $\text{Zn}(\text{NO}_3)_2$ .....	$\frac{1}{2}$ "
" cyanid, KCN.....	$\frac{1}{2}$ "	" Litmus paper.....	$\frac{1}{2}$ quire