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THE SCIENCE OF LAUNDRY WORK

MARGARET CUTHBERT RANKIN

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A MANUAL OF THE SCIENCE OF LAUNDRY WORK

FOR STUDENTS AND TEACHERS

BY

MARGARET CUTHBERT RANKIN

Head Teacher of Laundry Work, Technical College of Domestic Science, Liverpool;
First Class Certificate for Laundry Work; First Class Full Diploma for Cookery;
Certificated in Chemistry, Hygiene, and Physiology; First Class Dressmaking
Certificate (City and Guilds).

SECOND EDITION

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1908

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PREFACE

It has frequently been suggested to me that a book on these lines might be of assistance to Laundry students, especially intending teachers and others. I have compiled this small manual with great care, and hope it may prove of value to many enquirers.

MARGARET CUTHBERT RANKIN.

NOTE TO THE SECOND EDITION

In the Second Edition the opportunity has been taken to make some slight alterations, and to add the Appendix on page 141.

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THE SCIENCE OF LAUNDRY WORK

CHAPTER I.—WATER (H_2O)

Composition of Water

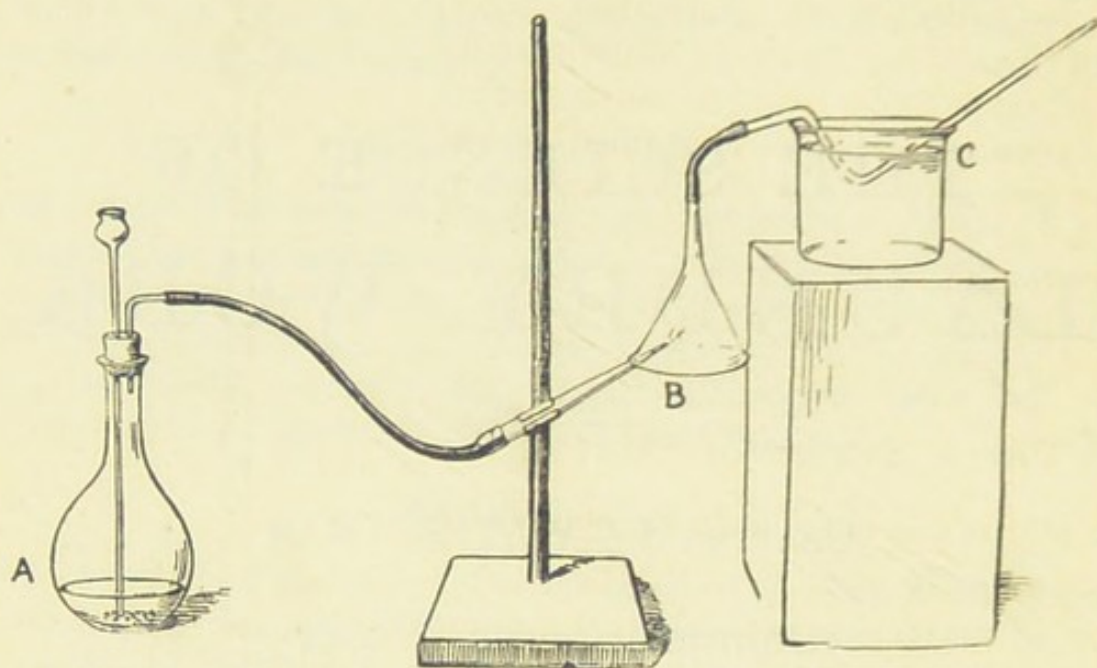
Water is composed of two gases, hydrogen and oxygen. The proportions in which these gases enter into its composition are two volumes of hydrogen and one volume of oxygen, or by weight one part of hydrogen and eight parts of oxygen.

The formation of water on the earth's surface is continually taking place; whenever any substance containing hydrogen is burned in air, water is one of the products of combustion. For example, if a cold substance is held for a few seconds over a coal-gas flame, large drops of water will condense on its surface. This is due to the oxygen of the air combining with the hydrogen of the gas to form water, which condenses when brought into contact with a cold body.

A few simple experiments which demonstrate that hydrogen and oxygen are constituents of water may easily be performed.

Experiment 1.—Prepare a Woulfe bottle. See that the corks fit properly and that the bottle is air-tight. Put a small quantity of zinc into the vessel and pour through the thistle-funnel as much diluted sulphuric acid as will cover it. Almost directly hydrogen gas will be given off by means of the delivery-tube, the end of which ought to be drawn to a fine point. This gas should be well

tested before a light is applied to the end of the tube, as it is very explosive if mixed with air. Allow the hydrogen to burn

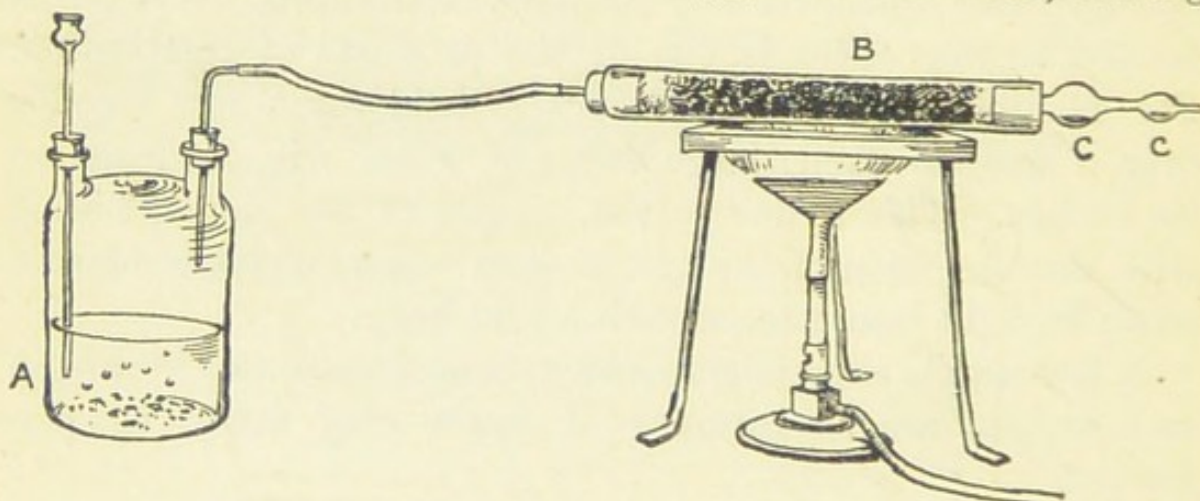


Apparatus to show Formation of Water by Jet of Hydrogen burning in Air

A, Acid and zinc; B, jet of hydrogen; C, water in bend of tube—cooled by beaker of water.

against a cold surface, when the water which is formed will condense and may be collected.

Experiment 2.—Pass hydrogen gas over heated copper oxide; the hydrogen combines with the oxygen of the oxide, leaving



Apparatus to show Formation of Water by passing Hydrogen over Copper Oxide

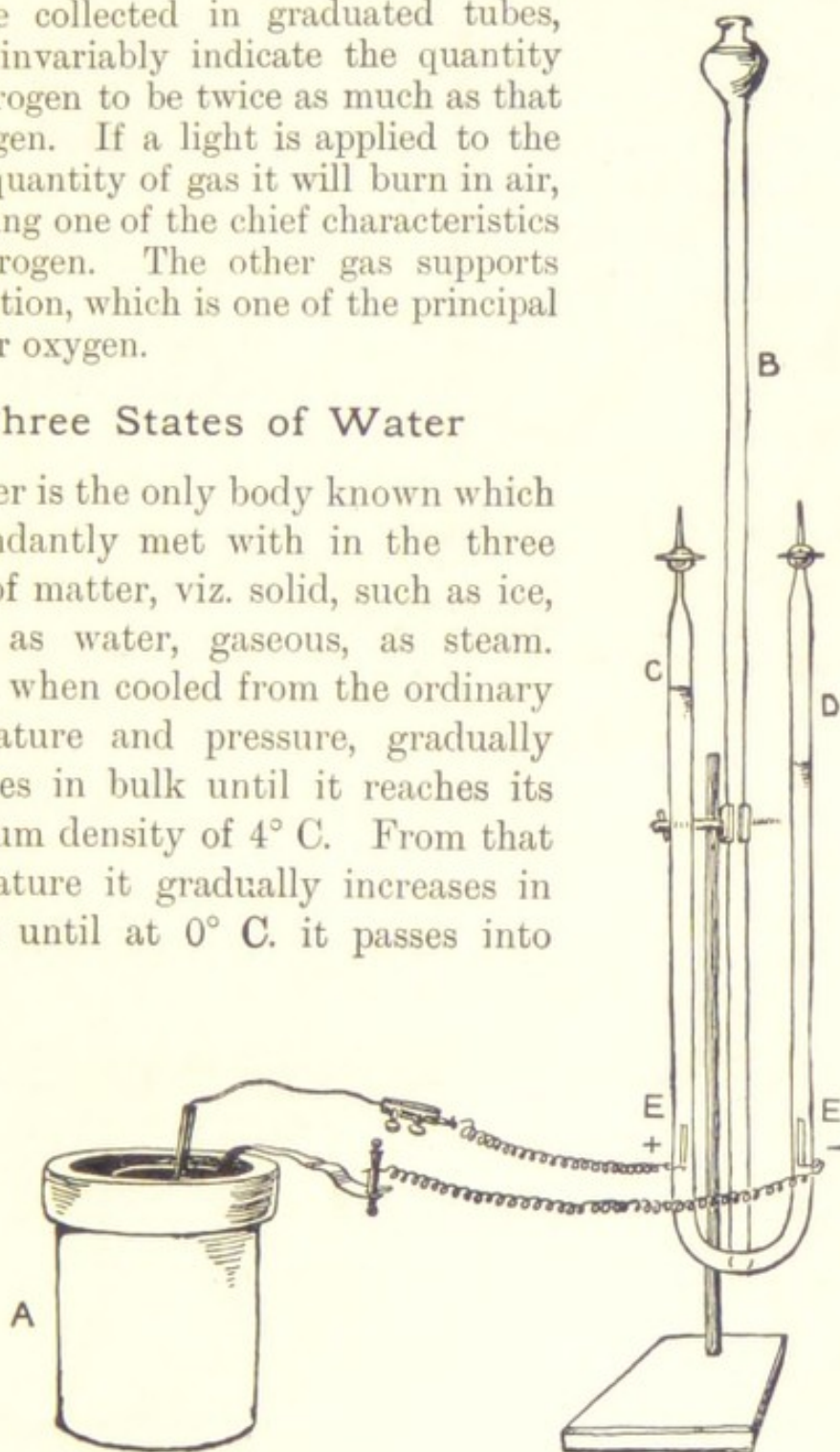
A, Acid and zinc; B, copper oxide; C, C, water

metallic copper in the tube and a deposit of water in the bulb at the end of the tube, proving the oxygen of the copper oxide and the hydrogen have combined to form water.

Experiment 3.—Pass an electric current through slightly acidulated water. Hydrogen and oxygen are generated, and may be collected in graduated tubes, which invariably indicate the quantity of hydrogen to be twice as much as that of oxygen. If a light is applied to the larger quantity of gas it will burn in air, this being one of the chief characteristics of hydrogen. The other gas supports combustion, which is one of the principal tests for oxygen.

Three States of Water

Water is the only body known which is abundantly met with in the three forms of matter, viz. solid, such as ice, liquid, as water, gaseous, as steam. Water, when cooled from the ordinary temperature and pressure, gradually decreases in bulk until it reaches its maximum density of 4°C . From that temperature it gradually increases in volume until at 0°C . it passes into



Apparatus for decomposing Water by Electrolysis

A, Battery; B, voltameter; C, D, oxygen and hydrogen; E, E, platinum electrodes

the solid state as ice. Above 0°C . it is liquid, and remains so until it is raised by heat to 100°C ., when its boiling-point is reached and it is changed into the gaseous state or steam.

Solvent Property of Water

Water is generally known as the great solvent agent. This particular property renders it quite impossible for pure water to be found in nature. In its passage through the air it dissolves various impurities, and still more after it reaches the earth. The impurities which concern us most as laundry students are chiefly soot, dust, carbon dioxide, calcium bicarbonate, calcium sulphate, and also the bicarbonate and sulphate of magnesium, so that these had better be dealt with apart from other forms of impurities.

Suspended and Dissolved Matter in Water

Suspension.—Many impurities are practically insoluble in water, the particles of which float in the liquid and are said to be in suspension, and if left for a time they will settle at the bottom of the vessel, and the water may be decanted in a comparatively clear condition. This form of impurity may be filtered from the water. A good example of suspension may be observed by mixing a small piece of starch with cold water; the small white particles float in the liquid and eventually settle, leaving the water clear as before.

Solution.—When a substance is dissolved in water it is diffused throughout the liquid and cannot be removed by filtration. For example, a piece of washing soda placed in water would disappear, or dissolve in the water, and could only be recovered by evaporating the whole of the liquid.

Various Impurities found in Water

The character of impurities found in water depends entirely upon the source from which the water is obtained. Rain-water contains, comparatively, a very small quantity of solid impurities, although the amount varies according to the district upon which the rain falls. Rain falling in country districts is almost free from solid matter, the substances principally dissolved being atmospheric gases, the chief one

for our consideration being carbon dioxide, as it increases the solvent power of water and enables it to dissolve certain limestone rocks which render it "hard".

In towns rain-water contains a comparatively large proportion of acid gases in solution, especially in the neighbourhood of chemical works, where the fumes escape into the air, and are dissolved by the water during its passage through the atmosphere. It has also present a large percentage of soot, dust, and organic matter, all of which render it quite unfit for laundry purposes.

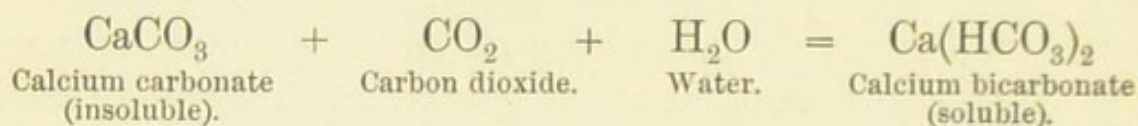
The water of rivers, lakes, wells, and springs varies in character according to the nature of the rocks over or through which it flows. In the neighbourhood of hard igneous rocks a fairly pure water is usually obtained; but if the rocks are more easily soluble in water containing carbon dioxide, as in the case of limestone or magnesite, the water is invariably impregnated with these substances. In many parts of Scotland and Wales where the rocks are so hard that water or gases have little action on them, the water is comparatively free from mineral matter. For example, the water of Loch Katrine, from which Glasgow receives its supply, is said to have in solution only from "2½ to 4 degrees of hardness". Throughout England, where limestone rocks abound, the water is generally highly charged with calcium salts, *e.g.* the water of the river Thames contains, approximately, 26 degrees of hardness (26 grains in the gallon). Hence water is usually classified as "soft" or "hard" according to the absence or presence of mineral matters held by it in solution.

Temporary and Permanent Hardness

Hardness in water is known as either temporary or permanent hardness. This classification depends entirely on the nature of the mineral matter present. Any water that can be softened by boiling is said to be temporarily hard, and its hardness is due to the presence of calcium and magnesium bicarbonates which are formed in solution from the calcium and magnesium carbonates by the carbon dioxide previously

dissolved by the water. When water charged by this gas passes over the above-named rocks it acts upon their surface and changes the substances from an insoluble carbonate to a soluble bicarbonate, and as long as the water contains the carbon dioxide, the mineral matter remains in solution. Directly it is removed the insoluble carbonate is precipitated. Water that cannot be softened by boiling is termed "permanently hard", and has usually calcium or magnesium sulphate in solution. The former of these salts is slightly soluble and the latter very soluble in water, and cannot be precipitated or removed except by evaporation, or by the aid of chemicals.

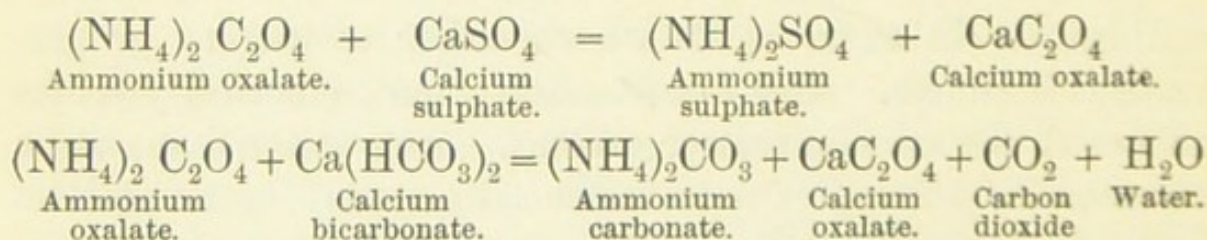
Equation to show the chemical change that takes place when carbon dioxide acts upon calcium carbonate, rendering it soluble:—



Simple Tests for Hardness in Water

Experiment 4.—Add a weak solution of soap to water and shake; if a permanent lather forms rapidly the water is said to be soft. If there is difficulty in producing a lather, and a curd forms on the top of the water, it is said to be hard.

Experiment 5.—Dissolve a few crystals of ammonium oxalate and add to the water; if it yields a white precipitate, there is calcium bicarbonate or calcium sulphate present. This test will precipitate a calcium salt. The chemical change is as follows:—Both substances are decomposed, and the ammonium combines with the carbonic or sulphuric constituent to form ammonium carbonate or sulphate, while the calcium combines with the oxalic constituent with the formation of calcium oxalate.



Boiling is a method usually adopted to discover the character of the hardness present in water. By this test the

calcium or magnesium carbonate is thrown out of solution, and may be filtered from the water, while the sulphates remain in solution.

To ascertain accurately the percentage of each mineral matter present, it is necessary to test with standard soap solution before and after boiling.

Use of Standard Soap Solution

Mix together 14 grammes of pure Castile soap, 67 cubic centimetres of distilled water, and 33 cubic centimetres of alcohol. Dissolve thoroughly, and standardize against a standard solution of calcium chloride, and it is ready for use. To perform accurately the qualitative and quantitative analyses for hardness in water, the above solution is put into a burette, and gradually passed into a given quantity of hard water until by shaking the water a lather is formed which remains for at least ten minutes.

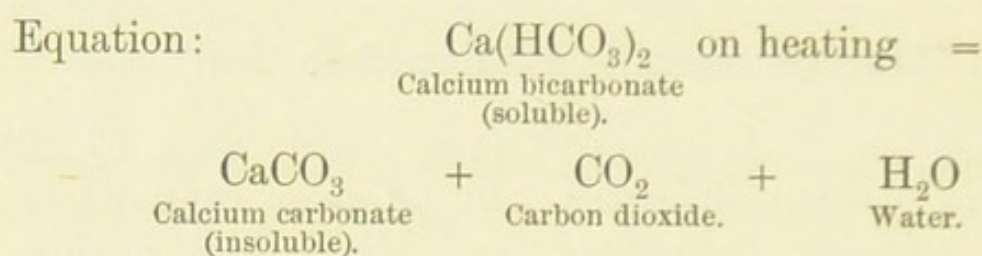
Different Methods of Softening Hard Water

Temporary Hardness.—When water is hardened by the presence of calcium bicarbonate or magnesium bicarbonate, the chief thing to aim at is to get rid, by one means or another, of the carbon dioxide which holds these substances in solution. To remove this gas from the water different methods may be adopted.

(a) *Exposure* of the water to the air is one of the most simple methods, and is frequently done for home use by people in country districts. If tubs are filled with hard water and left overnight, the gas gradually passes off, and the remaining insoluble carbonate settles to the bottom of the vessel, leaving the water comparatively soft; but care must be exercised, when decanting the water, not to disturb the sediment of lime, or the object will be defeated.

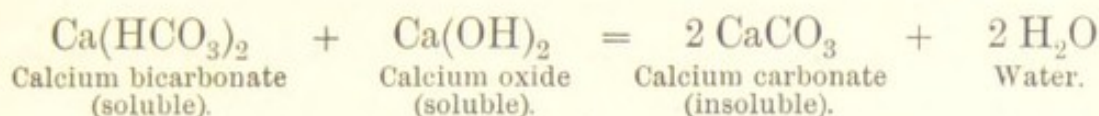
(b) *Boiling.*—Another method is that of boiling the water, when the carbon dioxide is expelled with the steam, and the insoluble carbonate is deposited and forms a hard crust on the

sides and bottom of the vessel, commonly known as "the fur of the kettle". The quantity of fuel required for the working of this system on a large scale would be tremendous, and not only that, the deposit of carbonate of lime on the boiler would be a serious drawback, so that it is seldom resorted to for the softening of large quantities of water.



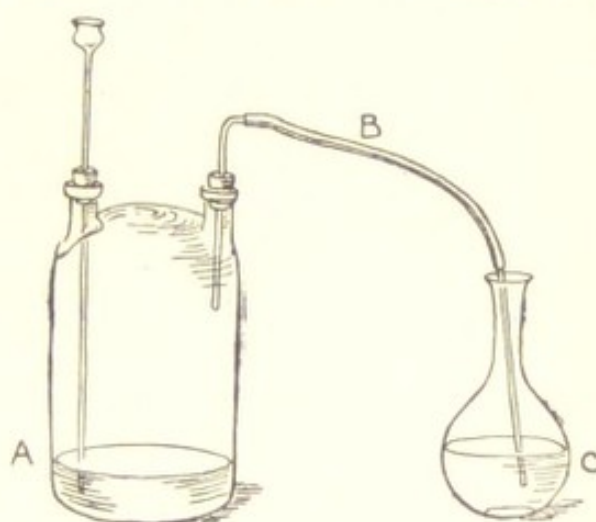
(c) *Porter-Clark process* is another method, and one that has been successfully used on a large scale by many water companies. This consists of the addition of lime-water (calcium hydrate) to the hard water, when both must be well agitated to enable them to mix quickly and thoroughly. A chemical change takes place between the two substances: the added calcium oxide combines with the excess of carbon dioxide in the water, forming insoluble calcium carbonate, and is precipitated with the original carbonate, which can no longer remain in solution. The water must be allowed to stand until the insoluble carbonates settle, or they may be, and are, more frequently removed by filtration. This is done by means of canvas sheets suspended across the tanks, and the water put under pressure. The canvas acts as a filter, keeping back the insoluble mineral matter and leaving the water comparatively soft. But if this method is to be successfully carried out two points must be carefully observed. The combining weights of calcium oxide and calcium bicarbonate and magnesia must be accurately understood, and also the water must be carefully tested for degrees of hardness present. Seven grains of calcium oxide are capable of removing eighteen grains of calcium bicarbonate; but unless one possessed the apparatus necessary for the accurate quantitative and qualitative testing of water, there would be a tendency to add an excess of lime-water which would increase the hardness instead of reducing it.

The chemical change that takes place when calcium hydrate is added to water hardened by calcium bicarbonate is as follows:—



Insolubility of calcium carbonate and solubility of calcium bicarbonate.

Experiment 6.—Put into a Woulfe bottle a few pieces of marble and add a little diluted hydrochloric acid. Immediately carbon dioxide is evolved. Pass this gas into lime-water (calcium hydrate); almost directly a turbidity appears, due to the combination of the carbon dioxide with the calcium oxide in the water, forming insoluble calcium carbonate. If an excess of carbon dioxide is passed into the water the turbidity disappears, the reason being that this gas in excess is capable of holding calcium carbonate in solution. In other words, it has changed it into calcium bicarbonate, which is soluble in water. If this water is boiled the gas is expelled and the turbidity again appears, proving that without the carbon dioxide the calcium carbonate cannot remain in solution.



Apparatus used for preparation of Hard Water by passing Carbon Dioxide into Lime-Water.

A, Calcium carbonate and acid; B, tube to conduct carbon dioxide; C, lime-water.

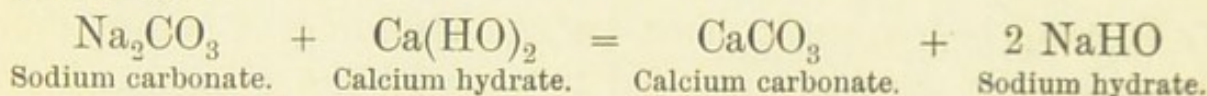
Permanent Hardness.—The term permanent hardness does not imply that the hardness cannot be removed, but that it is impossible to do so by boiling, and that chemicals, such as caustic or carbonate of soda or soap, have to be employed for the purpose.

1. The soda-lime process is a method of softening permanently hard water, indeed it acts upon both classes of mineral matter. It is a somewhat complex method, and is

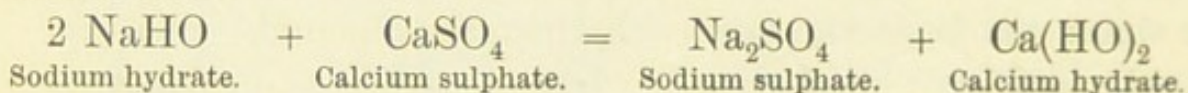
not usually done for ordinary home use, but is often the method adopted on a large scale for public laundries.

The mixture is prepared by boiling sodium carbonate (washing soda) with lime. After boiling for a time the lime and soda are thoroughly mixed and poured into a tank containing the hard water. Immediately a turbidity appears, which is due to the original lime having been precipitated. The water should be allowed to stand until the suspended lime settles to the bottom; this usually takes a number of hours, and to save time ought to be done overnight. By boiling the carbonate of soda with the oxide of lime, the former is reduced to a caustic soda, which, when added to the hard water, decomposes the calcium sulphate and forms sodium sulphate (which is harmless) and lime, which reacts upon any calcium bicarbonate which may be in the water.

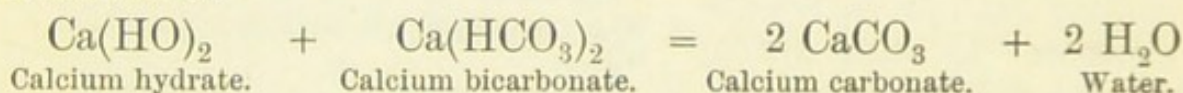
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Reaction 2:



Reaction 3:

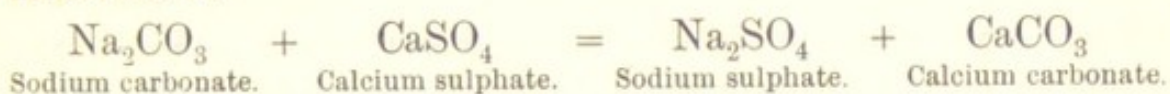


2. Washing soda is often used for softening water for home washing, and is one of the most economical and successful methods, provided an excess of soda is not added, which would destroy colour and delicate fabrics and also act corrosively on the skin. Comparatively, washing soda is one of the cheapest substances that can be used for softening water on a small scale, as it may be bought at an average cost of sixpence a stone. Theoretically, one grain of soda ($\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$) will overcome .475 of a grain of calcium sulphate, and the same quantity of soda will remove .566 of a grain of calcium bicarbonate.

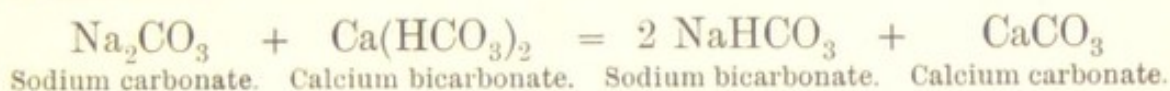
When sodium carbonate is added to hard water a double

decomposition takes place. The sodium of the soda combines with the sulphuric constituent of the sulphate to form a soluble sodium sulphate, and the calcium unites with the carbonic constituent, with the formation of insoluble calcium carbonate, which falls to the bottom of the vessel. A similar change takes place between the soda and the calcium bicarbonate. The calcium bicarbonate is converted to an insoluble carbonate, and the soda is converted into a sodium hydrogen carbonate or sodium bicarbonate.

Reaction 1:



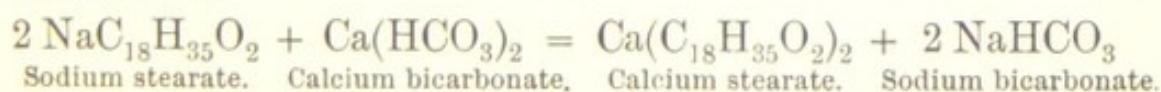
Reaction 2:



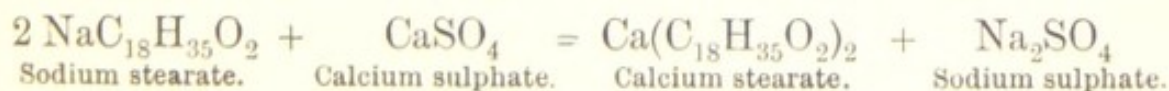
3. Soap is frequently used for the softening of water, but it is least to be recommended because of the great expense attending its use for that purpose, good yellow soap costing upon an average threepence halfpenny a pound.

When soap is added to hard water, as in the case of soda both substances are decomposed; the sodium of the soap combines with the carbonic or sulphuric constituent of the mineral matter, forming in one case sodium carbonate, which has cleansing powers, and in the other soluble sodium sulphate, while the stearic constituent of the soap unites with the calcium of both substances with the formation of calcium stearate (lime soap), which is insoluble in water, and floats as a grayish curd on top of the water, and unless an excess of soap is used it will stick to the clothes and is most difficult to remove.

Reaction 1:



Reaction 2:



Notes of Lesson on Water

Aims of Lesson—To teach

1. The composition of water.
2. Its properties.
3. The difference between hard and soft water.
4. How to remove hardness.

Apparatus—

A cold iron, bunsen burner, water—hard, soft, and dirty rain-water, also lime-water and a piece of ice. Kettle of boiling water. Starch, soda, soap solution, vinegar, filter-paper, black-board and easel, chalk, duster and towel, and two basins. Woulfe bottle, tube containing copper oxide, funnel and fittings for Woulfe bottle, zinc, and sulphuric acid.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Hold a cold iron for a few seconds over a gas flame.	<p>Obs. 1.—Large drops of water are formed on its surface.</p> <p>Sugg. 1.—(a) Water is composed of hydrogen and oxygen. (b) There is hydrogen in gas and oxygen in air.</p>	Inf. 1. —During the burning of gas the hydrogen contained in it and the oxygen of the air combine to form water.
Exp. 2. —Prepare apparatus according to the first illustration on page 10. Burn the hydrogen against the cold funnel which is connected to a bent tube resting in water.	Obs. 2. —Water collects in the bend of the tube.	Inf. 2. —When hydrogen is burned in air, water is formed.
Exp. 3. —Extinguish the burning hydrogen and connect the tube to a glass tube containing heated copper oxide.	<p>Obs. 3.—As the hydrogen passes over the oxide the colour of the copper oxide is changed from black to red.</p> <p>Sugg. 2.—Copper oxide is black, copper is red.</p>	<p>Inf. 3.—The hydrogen has combined with the oxygen of the copper oxide to form water.</p> <p>Inf. 4.—Water is composed of oxygen and hydrogen.</p>

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show ice, cold and boiling water.	Obs. 4. —Ice is solid, water is liquid, and boiling water gives off vapour.	Inf. 5. —Water exists in three states of matter—solid, liquid, and gaseous.
Exp. 4. —Put a piece of starch in a glass of water, and a piece of soda into another.	Sugg. 3. —In very cold weather water becomes solid; when boiled it is changed into steam, which is invisible, but condenses into vapour. Obs. 5. —Starch becomes broken up into small grains which float in the water. Soda mixes with the water and disappears.	Inf. 6. —Water will soften certain substances, and it dissolves others. Water has great solvent properties, and in consequence cleanses clothes.
Illus. 2. —Show a glass full of rain-water collected if possible from house-top in town, a glass of hard water, and one of soft.	Obs. 6. —Rain-water is dirty, and mud has settled on bottom of glass. No difference can be seen between the water in the other two glasses. Sugg. 4. —Rain-water in the country is clean and soft, and is best for washing.	Inf. 7. —As rain-water in towns is dirty it is quite unfit for washing purposes. Either of the other waters may be used for washing.
Exp. 5. —Put a little of the hard water and soft water into two test-tubes and add two or three drops of soap solution to each and shake.	Obs. 7. —A lather is formed on the soft water, and a curd floats in the hard water. Sugg. 5. —There is mineral matter in the hard water which it has dissolved from the rocks.	Inf. 8. —Soft water is best for washing, as the soap forms a lather at once and is not wasted. Inf. 9. —Hard water is not economical, as it requires so much soap to form a lather and remove hardness.
Exp. 6. —Put some specially prepared hard water into five glass vessels and put one aside for a short time.	Obs. 8. —A white powder will be seen on the bottom of the glass. Sugg. 6. —The mineral matter is held in the water by a gas called carbon dioxide which escapes into the air when the water stands.	Inf. 10. —If water is allowed to stand in the open air, the mineral matter will fall to the bottom of the vessel and the water will become soft.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 7. —Place another of the glasses of water over a bunsen burner flame and boil for a few minutes.	Obs. 9. —A white substance is deposited against the sides of the vessel. Sugg. 7. —Boiling expels the gas.	Inf. 11. —Boiling also softens water by removing the gas which held the mineral matter in solution.
Exp. 8. —Add a small quantity of lime-water to the third glass of hard water.	Obs. 10. —Water becomes turbid. Sugg. 8. —Mineral matter has again been removed, this time by addition of lime-water which has combined with the carbon dioxide gas and if allowed to stand will fall to the bottom of the glass.	Inf. 12. —Hard water can be softened by adding lime-water to it.
Exp. 9. —Pass turbid water through filter-paper.	Obs. 11. —Water becomes clear and lathers easily with soap.	
Exp. 10. —Put a drop or two of vinegar on the filter-paper with residue on it.	Obs. 12. —The acid and mineral matter effervesce. Sugg. 9. —When an acid is added to a carbonate it causes effervescence. Sugg. 10. —Water that can be softened by the above methods is termed temporarily hard water. Sugg. 11. —Water that cannot be softened by boiling is said to be permanently hard and has sulphate of lime and of magnesium dissolved in it.	Inf. 13. —This hardness in water is due to bicarbonate of calcium, and is temporarily hard water.
Exp. 11. —Dissolve a small piece of washing soda and add to fourth glass of hard water.	Obs. 13. —Water again becomes turbid. Sugg. 12. —Soda has also removed mineral matter. Sugg. 13. —Soda is cheap and easily obtainable.	Inf. 14. —Soda may also be used to soften hard water. It is economical and easily got, but must be used with care.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 12. —Add dissolved soap to fifth glass of hard water, and shake.	<p>Obs. 14.—A white curd appears in the water and gradually rises to the top.</p> <p>Sugg. 14.—The fatty acids of the soap have combined with the lime to form lime soap.</p>	Inf. 15. — Soap also softens water, but soap is dear, and this is a very expensive method.

Black-board Summary

WATER

Water is composed of $\left\{ \begin{array}{l} \text{two volumes of hydrogen} \\ \text{one volume of oxygen} \end{array} \right\} \text{H}_2\text{O}.$

Water exists in three states of matter:—

1. Solid, as ice.
2. Liquid, as water.
3. Gaseous, as steam.

Water has great solvent and cleansing properties.

Two chief kinds of water:—

1. Soft water.
2. Hard water.

Hardness in water is due to mineral matter:—

1. Calcium bicarbonate and magnesium bicarbonate.
2. Calcium sulphate and occasionally magnesium sulphate.

Water may be softened by:—

1. Exposure to air.
2. Boiling.
3. Addition of lime-water.
4. Addition of washing soda.
5. Addition of soap.

N.B.—Soft water is best for laundry purposes as it is more economical.

CHAPTER II.—SOAP

Composition

Soap is a chemical compound consisting of the sodium or potassium salts of fatty acids (*i.e.* An alkali such as caustic soda or caustic potash), with fatty acids and water.

The fatty acids are organic compounds containing carbon, hydrogen, and oxygen, and may be obtained from either animal or vegetable substances, such as stearic acid from tallow, palmitic acid from palm-oil, oleic acid from olive-oil, and linoleic acid from linseed-oil.

Caustic soda (sodium hydrate) is composed of sodium, hydrogen, and oxygen, and may be obtained from marine plants as barilla and kelp, or from common salt (sodium chloride). The latter is the chief source of the caustic soda of commerce. Caustic potash (potassium hydrate) may be obtained from wood ash, formerly the chief source; but commercially it is produced from potassium chloride, and is composed of potassium, hydrogen, and oxygen. This alkali is used chiefly in manufacture of soft soaps.

The combining weights of caustic soda and the fatty acids are in the ratio of 11·9 per cent of caustic soda, 88·1 per cent of fatty acids, but water being an absolute necessity, reduces considerably the percentage composition of the above substances. The average composition of a white curd soap may be taken as follows:—

Fatty acids	...	...	...	64·48 per cent
Caustic soda	...	...	...	7·07 „
Water	...	...	...	28·45 „

But soap made by mixing the exact combining proportions of these substances is termed an overfatted soap, and is not suitable for ordinary household use. Hence all soaps, even the most refined, must have even to a small degree an excess of alkali. The cheaper soaps usually have a large proportion of alkali in excess, which reduces them in quality and price.

Manufacture of Hard Soap

Soap is usually made on a large scale by boiling the fats and oils (which are compounds of glycerine with fatty acids) with caustic soda and water in large vats. Sometimes as much as forty to sixty tons is prepared in one vessel. During the process of boiling, the fats and oils are decomposed, and the caustic soda combines with the acid constituents of these organic compounds, and the glycerine of the fat is set free. When the process of saponification is completed, a quantity of salt is added which immediately throws the soap out of solution, thus separating it from the glycerine and refuse and also the water, which has been largely in excess, all of which may be drawn off at the bottom of the vat.

The soap is then remelted and poured into movable metal frames, which are lime-washed to prevent it adhering to the sides. When the soap becomes solid it is cut into bars, stamped and packed, and is ready for the market.

Impurities in Soap

As pure curd soap is comparatively expensive and the average buyer prefers to obtain a cheaper article, the manufacturer is obliged to add certain substances which cheapen the cost of production and enable him to offer to the public a soap at a little over half the price that he otherwise could.

Some of these substances greatly increase the cleansing power of soap, and so far are useful; but if added in excess they act corrosively on the skin, and also destroy the colour of clothes, and in some cases the fibres of the material on which the soap is used.

A highly-adulterated soap is also less economical, as it dissolves more easily in water, and is in consequence more wasteful.

Some of the principal impurities in soap are carbonates of soda and potash, silicate of soda, resin, and water.

The *carbonates of soda and potash* and the silicates are dissolved and added to the soap after saponification is completed,

and the refuse has been removed; the whole is then boiled for a time, to thoroughly mix the different substances, before it is poured into the frames to solidify.

Silicate of soda is composed of silicon, sodium, and oxygen combined together and water. It is obtained by melting silicious sandstone and combining it with caustic soda and water, which forms a clear solid substance soluble in water. This compound is valuable owing to its great cleansing powers, but it ought to be sparingly used as its effects on fabric are injurious.

When used in soap-making it acts as a substitute for both fatty acids and alkali, and as it is very cheap it reduces the price of soap considerably. It must be added while the soap is very hot, and thoroughly mixed before solidification takes place.

But there are evils pertaining to the use of silicate of soda. In the first place "it is a great absorbent of water", and also being in itself a very cheap compound, it aids the soap-maker to charge the public at the rate of good soap for cheap silicate of soda and water.

Resin.—Resin is often added to yellow soap during the process of boiling, indeed the characteristic colour of yellow soap is said to be due to that ingredient. It is cheap, but it does not saponify. It is said to whiten fabric, as it removes from the material small quantities of colouring matter, which is not removed either by soap or alkali, and is therefore useful for cleansing purposes.

Water in excess.—Soap may be made to take up a large quantity of water in excess. Sometimes as much as 50 to 60 per cent of water may be found in inferior soaps, and as a good soap when freshly made should not contain more than 25 to 28 per cent, it can easily be seen to what extent water can be used as an adulterant.

There are even worse adulterants added to soap than those already mentioned. These are in the form of "flour, fine ashes, and finely-powdered pumice-stone, clay, chalk, talc, and sometimes sulphate of barium". All of which are added to give

bulk to the soap, and enable the maker of such material to sell to the public a cheaply produced article for which he charges the price of a good ordinary soap.

Properties of Soap

(a) It saponifies and emulsifies grease, and forms a lather with water.

(b) It has great solvent and cleansing powers. As water alone cannot render grease soluble, it is impossible to cleanse most clothes without the aid of an agent which is capable of so doing. For example, if a small quantity of water and oil are mixed together, and left standing for a few minutes, the oil being lighter than water rises to the top; but on the addition of a few drops of soap solution and the mixture slightly shaken, a white emulsion is formed. In other words, the soap has coated the particles of oil, which enables the water to hold them in suspension.

Of all the cleansing agents known, soap is the only one that readily forms a lather with water. The change is said to be somewhat as follows. Soap when mixed with water is decomposed into two substances, viz.: Sodium hydrogen stearate (an acid salt), which is capable of forming a lather with water, and alkali, which has been displaced by the hydrogen of the water. This free alkali readily combines with the grease in clothes, producing a form of soap which is easily removed by water. The lather-forming property of soap aids the laundress greatly in regulating the amount of soap necessary for the actual work to be done, as the degree of lather on the surface of the water indicates excess, sufficiency, or lack of soap.

The cleansing and solvent properties of soap are entirely due to the alkaline constituent; the fatty acids being employed only to modify the injurious property of the alkali.

Simple Tests for Composition of Soap

Experiment 7.—Put a solution of soap in a test-tube and add a few drops of hydrochloric acid. The soap is decomposed, and

a white greasy substance (fatty acid) is thrown to the top, and a solution of sodium chloride remains at the bottom of the tube.

Experiment 8.—Place a small piece of soap on the end of a platinum wire and hold it in the bunsen flame. If sodium is present it will burn with a rich yellow flame.

Tests for various kinds of Impurities in Soap

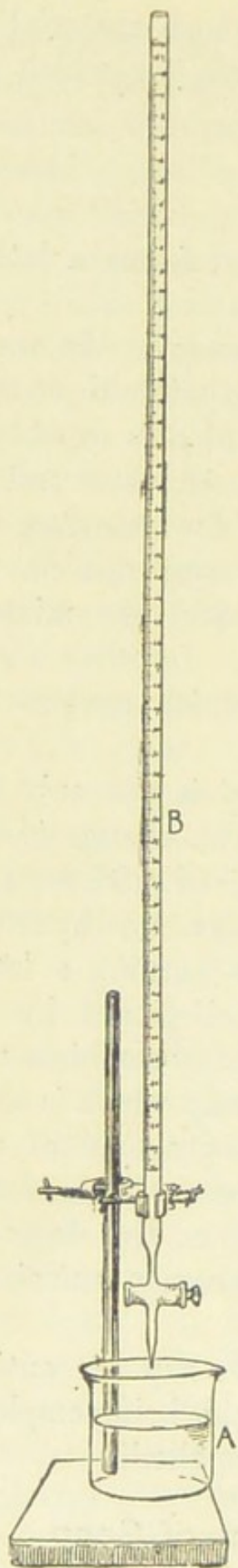
FREE CAUSTIC ALKALI

Experiment 9.—Take a given quantity of soap and dissolve it in nearly absolute alcohol, when the free caustic alkali will pass into solution. Filter the solution, then add a few drops of phenol phthalein. If a pink coloration appears there is free alkali present. To determine the amount of free alkali in any soap, a standard solution of an acid should be carefully added to an alcoholic solution of the soap, prepared as above, until the colour of phenol phthalein disappears entirely. By using acid of a given strength the percentage of free caustic alkali can be determined.

CARBONATES OF SODA AND POTASH

Experiment 10.—To the residue left from alcoholic solution add a few drops of dilute hydrochloric acid. If carbonate is present an effervescence will occur, and carbon dioxide is evolved, which will produce turbidity if passed into lime-water.

Experiment 11.—*Excess of Water.* Cut a small piece of soap into thin pieces. Weigh carefully, and dry slowly, and again weigh. The difference in weight of soap before and after drying equals the weight of water in excess. Soap containing excess of water usually shrinks considerably during the process of drying.



Apparatus for Estimation of Free Alkali in Soap. A, Soap solution; B, acid.

Experiment 12.—*Ash, Clay, &c.* To discover any of the insoluble earthy substances, dissolve a piece of soap in distilled water or alcohol in a white vessel, and allow it to stand. After a time the insoluble matter will settle to the bottom, and the liquid may be poured carefully off. The sediment (if any) represents the adulteration, the nature of which may be determined by testing.

Blue Mottled Soap

Blue mottled soap is usually a compound soap, and is made from darker fats and oils, caustic soda, and water. After preparation, and while it is still hot, silicate of soda is added, the quantity varying according to the quality of the soap required. This compound makes a good hard soap for household work, and costs less than the best yellow soap. Ultramarine, and in some cases an iron compound, is added to give it its characteristic appearance.

Percentage composition of blue mottled soap, an average of

50	per cent of fatty acids
8	„ alkali (caustic soda).

The other 42 per cent may be divided between silicate of soda and water, and probably other forms of adulteration.

Soft Soap

Soft soap is prepared from fats and oils, which are often obtained from refuse fats and crude oils, and caustic potash, and contains also a large proportion of water.

On analysis an average soft soap may contain about—

41.36	parts of fatty acids
9.18	„ caustic potash
43.7	„ water
5.68	„ glycerine.

The process of making this soap slightly differs from that of hard soap; the glycerine being retained, and of necessity a fair amount of refuse, which, in conjunction with the crude fats and oils, tend to make the use of the soap objectionable except for very dirty clothes and scrubbing purposes. It will

also be observed that the proportion of water is largely in excess of that in most hard soaps. After the boiling process is completed the soap is poured into barrels, and when cold it is ready for sale, thus doing away with many of the finishing processes that are necessary for hard soap.

Purchase, Care, and Use of Soap

When buying soap it is desirable to procure that made by a well-known reliable manufacturer, as one is less likely to get an inferior article. It is also better to buy it in large quantities, say from half a hundredweight to a hundredweight, as large quantities are usually sold at a considerable reduction in price, and soap improves in quality and durability by keeping.

It should be cut into pieces, and kept in a warm place to dry slowly, until it becomes quite hard, as well-dried soap dissolves less quickly in water and is in consequence more economical.

Soap may be used as a solid, or it may be dissolved and used as a liquid; in whatever form, its action is that of a grease solvent and purifying agent. It is used in the solid or hard state for strong material without colour, when its strength may be concentrated by rubbing it on the particularly dirty parts, so that they may be more easily and thoroughly cleansed.

“Dry Soap Powder”

The composition of so-called dry soap varies considerably, but if that produced by a good maker were analysed it probably would contain an approximate proportion of the following ingredients:—

50	per cent of soda in one form or another
34	„ „ moisture
16	„ „ yellow soap.

The soda used is chiefly a mixture of soda crystals, soda-ash (both are forms of carbonate of soda), and caustic soda. The crystalline soda must be reduced to a powder by machinery, then thoroughly mixed with the other two forms, and the soap added. The mixture is again put through a process of

grinding; when smooth it is removed from the machine and allowed to cool. It is then made up into neat packets, varying in size and weight, and is ready for sale.

Some of the cheaper dry soaps are usually adulterated with chlorides, also at times sulphates and silicates are added. The advantage of using "dry soap powder" is that it has a lather-forming property, and owing to the fatty acids in its composition, its injurious power is slightly modified.

On the other hand, soap powder is principally composed of soda and water; and as washing soda does not cost more than one-fifth of the price of "dry soap", it would be more economical for the housekeeper to use that substance with the addition of a little soap solution to the water, which would form a lather equally as well, and the work of cleansing would be as effectual, as when "dry soap" is used.

Notes of Lesson on Soap

Aims of Lesson—

1. To teach the composition of soap.
2. To enable one to distinguish between a good and inferior soap.
3. To teach the properties of soap.
4. To teach how to purchase, preserve, and use soap

Apparatus—

Three pieces of soap—good, inferior, and soft soap. Hydrochloric acid, test-tubes, filter funnel, filter-paper, piece of platinum wire, bunsen burner, caustic soda, piece of tallow, common salt, piece of resin, and a piece of well-dried curd soap, phenol phthalein solution, water, beakers. Black-board, easel, and chalk. Piece of calico.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1.—Show class a piece of good yellow soap, a piece of inferior, and soft soap.	Obs. 1. —Good soap is lighter in colour and more solid than inferior soap. Soft soap is a jelly-like substance, and is dark in colour.	Inf. 1. —Soap is of two kinds, hard and soft.
	Sugg. 1. —Inferior soap is adulterated, and wastes more quickly.	Inf. 2. —Hard soap varies in quality; poor quality is not good to use.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Dissolve a small piece of hard soap in water, and add a few drops of hydrochloric acid.	<p>Obs. 2.—A white greasy substance separates and floats on top of the liquid, and the water beneath is salt to taste.</p> <p>Sugg. 2.—This white substance is the fat part of the soap.</p>	Inf. 3. —Fats enter into composition of soap.
Exp. 2. —Put a small piece of soap on the end of a platinum wire and hold in bunsen flame.	Obs. 3. —The flame burns with a rich yellow colour.	
Exp. 3. —Burn a piece of caustic soda in bunsen flame.	Obs. 4. —The flame has exactly the same colour.	Inf. 4. —Soap contains a sodium compound.
Exp. 4. —Place in a beaker a small piece of tallow and a little caustic soda and water; boil for a short time.	<p>Obs. 5.—The tallow, soda, and water form a white, milky-looking substance which mixes with water.</p> <p>Sugg. 3.—Soda has emulsified and saponified the tallow.</p>	
Exp. 5. —After boiling add a little common salt, and allow it to stand a short time.	<p>Obs. 6.—The white substance forms a curd which floats on top of a watery liquid.</p> <p>Obs. 7.—It feels soapy to the touch, and it smells and tastes soapy.</p>	<p>Inf. 5.—Fat, water, and caustic soda when boiled together make soap.</p> <p>Inf. 6.—Salt is used to separate soap from water, glycerine, and refuse.</p>
Illus. 2. —Show a piece of well-dried good soap and a piece of well-dried inferior soap.	<p>Obs. 8.—Good soap is very hard and solid. Inferior soap is also hard, but has shrunk greatly, and a white powder is on its surface.</p> <p>Sugg. 4.—When a large quantity of water is in soap, it shrinks as it is dried.</p>	Inf. 7. —Inferior soap has had excess of water in it, and is adulterated and is not good to use.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 6. —Put a drop or two of acid on inferior soap, and also a drop on a piece of soda.	Obs. 9. —The acid and white powder effervesce, also the soda.	Inf. 8. —Inferior soap has soda on its surface, which indicates it is further adulterated, and is fraudulent and not good to use.
Exp. 7. —Dissolve soap in alcohol, filter, and add phenol phthalein.	Obs. 10. —The liquid becomes pink.	Inf. 9. —Phenol phthalein gives pink coloration in presence of free caustic alkali.
Exp. 8. —Place a small quantity of the residue in a test-tube and add dilute hydrochloric acid, and pass fumes into lime-water.	Obs. 11. —Substances effervesce, and lime-water becomes turbid. Sugg. 5. —When acid is brought into contact with a carbonate, effervescence is produced.	Inf. 10. —A carbonate is present.
Illus. 3. —Show a piece of white curd soap, a piece of yellow soap, and a piece of resin.	Obs. 12. —Curd soap is white, the other is yellow, and resin is golden brown. Sugg. 6. —Resin is one of the ingredients of yellow soap; it absorbs water and mixes with alkali.	Inf. 11. —Resin gives soap its yellow colour.
Exp. 9. —Put a piece of well-dried soap and a piece of fresh soap into a glass of boiling water.	Obs. 13. —The fresh soap dissolves more quickly than the hard soap.	Inf. 12. —Very hard soap is more economical, as it does not melt so quickly as fresh soap.
Exp. 10. —Put a greasy cloth into water, and rub.	Obs. 14. —The grease is not removed by the water.	Inf. 13. —Water will not cleanse greasy clothes.
Exp. 11. —Add a little soap solution to water, and rub.	Obs. 15. —The grease is at once dissolved, and is washed out in the water.	Inf. 14. —Soap is necessary to dissolve grease, and is in consequence one of the best cleansing agents.

Black-board Summary

SOAP

Soap is composed of:—

1. Fatty acids of tallow and oils combined with
2. Alkali, *e.g.* caustic soda or potash.
3. Water.

Soap may be adulterated by use of:—

1. Water in excess.
2. Alkali of excess.
3. Carbonates of soda or potash.
4. Resin, which makes soap yellow.

Properties of soap:—

1. It either saponifies or emulsifies grease and renders it soluble in water, or else capable of forming an emulsion with water.
2. It removes dirt, and consequently cleanses clothes.
3. It is alkaline to litmus.

Care of soap:—

1. Well-dried soap is less wasteful than fresh soap, hence soap should be bought and dried before using.

N.B.—The best soap should always be bought, as it has less adulteration and is more profitable.

CHAPTER III.—SODIUM CARBONATE ($\text{Na}_2\text{CO}_3, 10\text{H}_2\text{O}$)

Sodium carbonate, commonly known as washing soda, is a definite chemical compound containing sodium, carbon, and oxygen, and water of crystallization. The fact that the above substances are constituents of washing soda may be simply demonstrated, and for the present purpose it will be better to omit the quantitative tests which are more complex and not absolutely necessary.

Experiment 13.—Place a piece of sodium carbonate on the end of a piece of platinum wire or glass rod, and hold for a few seconds in the bunsen flame, which will burn with a rich yellow colour, thus indicating the presence of sodium.

Experiment 14.—Again put a few crystals into an evaporating basin and gently heat; the soda will dissolve in its water of crystallization. If the heat is continued the water will pass off, and a white powder of sodium carbonate will remain. This form of sodium carbonate is known as soda-ash, and is much stronger than the crystalline or hydrated form. If the soda is

weighed before and after heating, the difference in weight will equal the amount of water lost.

Experiment 15.—Put a small quantity of the soda-ash into a Woulfe bottle, and add a few drops of hydrochloric acid. The substances effervesce, and a gas is evolved which, if passed into lime-water, produces turbidity. Both of these changes prove the presence of carbon dioxide. Therefore sodium carbonate contains carbon and oxygen.

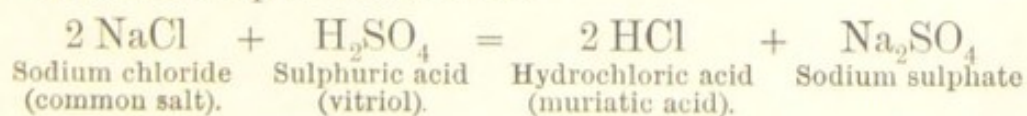
Different Sources of Sodium Carbonate

Native sodium carbonate is found in an impure state in Western America, and also on the shores of certain soda lakes in Egypt and Hungary. It can also be obtained from marine plants, such as barilla, found on the coast of Spain and along the shores of the Mediterranean, and also kelp, found in Ireland and Scotland.

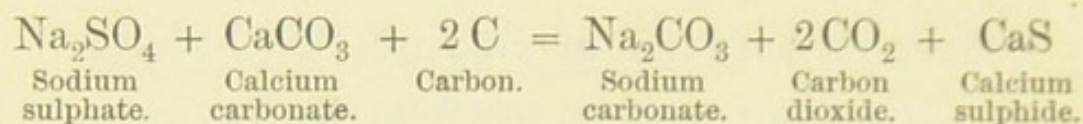
The barilla plant is considerably rich in soda, containing from 20 to 30 per cent, but independent of this fact, kelp, which is less valuable, yielding only from 2 to 7 per cent, was formerly largely used owing to the heavy duties levied on the importation of barilla.

The sodium carbonate of commerce is chiefly obtained from common salt. The two principal methods adopted for its manufacture are known as the Leblanc and the Solvay respectively. The former process is the older of the two, and is worked somewhat as follows:—Approximate quantities of common salt and sulphuric acid are mixed and heated in a furnace until a decided chemical change is produced, and two entirely new substances formed, namely sodium sulphate and hydrochloric-acid gas, which acid gas used to pass in considerable quantities into the air and proved very injurious to health and plant life in the neighbourhood of the works, but now it is collected and decomposed, the chlorine of which is utilized in the manufacture of bleaching-powder.

The chemical change during the first stage of the manufacture of soda is represented thus:—



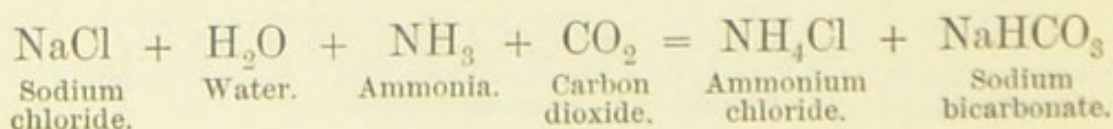
The sodium sulphate is then mixed with calcium carbonate and coal and again roasted, when another chemical change is produced. The sodium of the sulphate combines with the carbon dioxide of the calcium carbonate, resulting in sodium carbonate, and the sulphuric constituent and calcium combine with the formation of calcium sulphide. Second chemical change:—



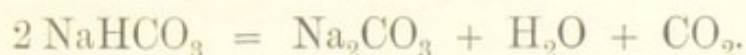
Sodium carbonate dissolves readily in water, and the insolubility of calcium sulphide renders the separation of the two substances practically easy by dissolving the soda in water, decanting it, and leaving the less soluble residue. The water is evaporated, and crude sodium carbonate remains, commonly known as soda salt. This when ignited forms the "soda-ash" (Na_2CO_3) of commerce. To convert this into the sodium carbonate of commerce, it is dissolved in a small quantity of water, placed in vessels with rods suspended across, to which the soda adheres in large crystals, which are broken up and sent to the market as washing soda. This form of soda, having a large amount of water in its composition, is less strong in its action, and consequently less injurious than soda-ash, and is also less expensive.

The Solvay process is less complex, but the initial expense is said to be considerably greater than the black-ash process. The method of production consists of passing ammonia gas into a strong solution of salt; then into this ammoniacal liquor is passed carbon dioxide, which reacts with the ammoniacal brine, producing a precipitate of sodium bicarbonate, and leaving ammonium chloride in solution. There are different methods of separating the two substances, centrifugal action being one of them.

Chemical change during process of manufacture:—



The bicarbonate on heating evolves carbon dioxide, and is reduced to the normal salt (soda-ash)



The remainder of the process of converting the soda-ash into the crystalline form is similar to that described above.

Properties of washing soda as recognized in the laundry.

1. It is soluble in water. Without this property soda would be practically useless for cleansing purposes.

2. It has an alkaline reaction on litmus paper; *e.g.* if a piece of red litmus paper is put into a solution of washing soda, the colour is changed to blue.

3. It saponifies grease and acts on dirt, rendering both of these substances removable by water. This grease solvent property is one of the most important, as it is impossible to cleanse clothes without the aid of an agent which is capable of converting these oily substances into a condition that enables them to mix with water. The action of soda on fats and oils is similar to that of soap, which has already been described on page 27.

4. It destroys the colour of prints or material otherwise coloured. The action in some cases is that of fading the colour, and at times removing it almost entirely. In other cases it softens the dyes, and enables the one colour to run into the other, until the article is almost unpresentable. The chemical action of soda (caustic or carbonate) on dyes is exceedingly complex.

5. It has the property of shrinking woollen material, making it hard and felted, and deprives it of its elasticity. See article on Wool (page 116).

6. It acts corrosively on the skin when used in the washing water, especially if a strong solution is employed, dissolving the natural oil from the pores of the skin, dries, and makes it hard, and eats into the flesh, forming small round holes, especially in the fingers. The three last-mentioned properties condemn the use of washing soda for the cleansing of any description of coloured clothes, and also for any kind of

woollen material. Yet it has its advantages, and these ought to be considered. A solution of soda added to the steeping water for very dirty coarse clothes lessens the labour, time, and expense of cleansing. A small quantity may also be added to the washing water, especially if the work is done in a dolly tub when the hands are not used for rubbing. A little may even be added to the water in the boiler. It will help to purify articles such as bath towels, which are most difficult to keep a good colour, and also for kitchen towels and dusters or any other very dirty cloths.

To Keep Washing Soda

It is advisable to keep soda in a jar covered with a lid, especially if the atmosphere of the room is dry, as soda exposed to dry air effloresces (*i.e.* yields some of its water of crystallization), leaving a white powder, which is therefore stronger than soda crystals (washing soda), and is injurious to certain kinds of clothes.

Notes on Lesson on Sodium Carbonate (Washing Soda)

Aims of Lesson—

To teach composition, sources, properties, and use of washing soda. To carefully note the destructive action of soda on colours, skin, and certain fabrics.

Apparatus—

Black-board, easel, towel, duster, chalk, piece of platinum wire, washing soda, soda-ash, bunsen burner, Woulfe bottle, beaker, evaporating basin, test-tubes, jug of water, litmus paper, common salt, acid, lime-water, boiling water, and a piece of red flannel.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show a piece of washing soda and a small quantity of soda-ash.	Obs. 1. —Washing soda is a solid crystalline substance, the other is a powder. Sugg. 1. —Both substances are called sodium carbonate.	Inf. 1. —There are two kinds of sodium carbonate, crystalline and powder.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Put a piece of soda on the end of platinum wire, and hold in bunsen flame. Burn also a little of the powder.	Obs. 2. —In both cases the flame becomes golden yellow. Sugg. 2. —When sodium is burnt it gives a yellow colour to the flame.	Inf. 2. —Both substances contain sodium.
Exp. 2. —Put a few pieces of washing soda into a Woulfe bottle or test-tube and add a few drops of acid, and pass the gas into a vessel containing lime-water.	Obs. 3. —The two substances effervesce, and a gas is evolved which turns lime-water milky. Sugg. 3. —Carbon dioxide turns lime-water milky.	Inf. 3. —Other constituents of sodium carbonate are carbon and oxygen. Therefore washing soda is composed of sodium, carbon, and oxygen.
Exp. 3. —Put a few crystals of soda into a test-tube or evaporating basin, and gently heat.	Obs. 4. —The soda becomes liquid. Sugg. 4. —It dissolves in its water of crystallization, and water is driven off.	Inf. 4. —Crystalline washing soda has water in its composition.
Exp. 4. —Put a little of the soda-ash in test-tube and heat.	Obs. 5. —No change.	Inf. 5. —Soda-ash has no water in its composition, and is much stronger than the crystalline form.

The teacher should here explain the source and manufacture of sodium carbonate, showing specimens of different materials used.

Exp. 5. —Put a piece of soda into water.	Obs. 6. —Soda disappears or dissolves in the water.	Inf. 6. —Soda has the property of being soluble in water.
Exp. 6. —Dip a piece of red litmus paper in soda solution.	Obs. 7. —The paper becomes blue. Sugg. 5. —Alkalies turn red litmus blue. Sugg. 6. —Sodium carbonate is derived from the combination of an alkali and an acid, and is called a salt.	Inf. 7. —Soda is a salt with a strong alkaline reaction.
Exp. 7. —Put a few drops of oil into soda solution and shake.	Obs. 8. —The mixture becomes white. Sugg. 7. —The soda has partly saponified the oil, enabling it to mix with the water.	Inf. 8. —Soda emulsifies oil and grease, and is a great cleansing agent.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 8. —Dissolve a piece of soda in very hot water, and put a piece of red flannel in solution.	Obs. 9. —The colour runs out of the flannel, and the fabric becomes hard and thick.	Inf. 9. —Soda destroys colour and fabric, and should never be used for coloured clothes.
Illus. 2. —Show a piece of soda that has been exposed to the air for a few hours.	Obs. 10. —Soda is covered with a white powder.	Inf. 10. —Soda when exposed to air gives up its water and becomes stronger, consequently it must be kept in a covered jar.

Black-board Summary on Washing Soda

Kinds:—

1. Soda crystals, a hard solid.
2. Soda-ash, a powder.

Composition:—

1. Sodium, carbon, oxygen, and water.
2. Sodium, carbon, oxygen.

Sources:—

- (a) The shores of soda lakes, and in America.
- (b) Marine plants, *e.g.* barilla and kelp.
- (c) Common salt (commercial source).

Properties:—

1. Soluble in water.
2. Emulsifies grease.
3. Destroys colour, fabric, and the skin.
4. It has a strong alkaline reaction.

N.B.—Soda should never be used for coloured clothes. Soda becomes stronger if exposed to the air, and should be kept covered.

CHAPTER IV.—ALKALIES

The alkalies most commonly known are sodium hydrate (caustic soda), potassium hydrate (caustic potash), and ammonium hydrate (ammonia solution). The two first named are not used in laundry work except in combination with fatty acids of certain fats and oils in the form of soap. If used in a pure state, their action would be too destructive, in

some cases dissolving the fabric, and invariably destroying the colour of the material.

Sodium Hydrate (NaHO)

Sodium hydrate (NaHO) is compounded of sodium, hydrogen, and oxygen in the ratio of twenty-three parts of sodium, one of hydrogen, and sixteen of oxygen.

Experiment 16.—Heat a piece of sodium hydrate on the end of a platinum wire; yellow coloration of flame indicates the presence of sodium.

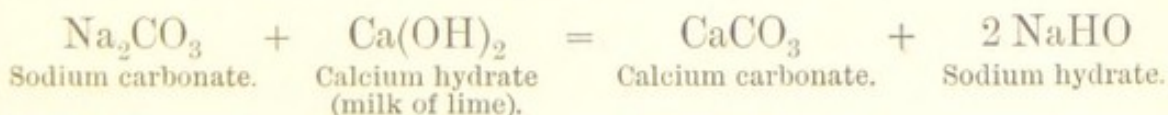
Experiment 17.—Place a small piece of sodium on water. A violent chemical action is set up; the sodium acts on the water, liberating hydrogen gas, and forming with the water caustic soda, which may be recovered by evaporation of the liquid.



Sodium dissolving in Water
with Formation of Sodium Hy-
drate

Caustic soda is now largely made by the electrolysis of salt solution. The ultimate source of caustic soda is the same as that of sodium carbonate, and need not again be described.

Sodium hydrate is prepared in large quantities from sodium carbonate by boiling it with milk of lime until it is decomposed and gives up its carbon dioxide, which combines with the milk of lime, or calcium hydroxide, to form calcium carbonate, which is insoluble in water, and may be filtered from the solution. The sodium carbonate at the same time is converted to sodium hydrate in solution, which on evaporation of the water is found as a residue.



Caustic soda is chiefly used in the manufacture of all hard soaps. It must be kept in a perfectly air-tight vessel; if exposed to air it deliquesces, and also absorbs carbon dioxide, giving sodium carbonate.

Potassium Hydrate (KHO)

Caustic potash is composed of potassium, hydrogen, and oxygen. The simple tests already described for the composition of caustic soda may also be successfully applied to potassium hydrate. The reactions are the same in each case, except when the substance is heated in a bunsen flame on a platinum wire, potassium yielding a violet-coloured flame instead of yellow.

Potassium hydrate for industrial purposes is obtained from potassium carbonate. The process of manufacture is also limited to that for the preparation of caustic soda, and need not again be explained. This alkali is chiefly used in soft soap-making. It has a stronger chemical action than caustic soda, and in consequence renders soap more injurious. It is also said to have a stronger affinity for water.

Various Properties of Sodium and Potassium Hydrate

They are soluble in water.

They are alkaline to litmus, *e.g.* turn red litmus blue.

They have caustic or burning properties.

They have great solvent and cleansing powers; it is this property that renders them so valuable in laundry work.

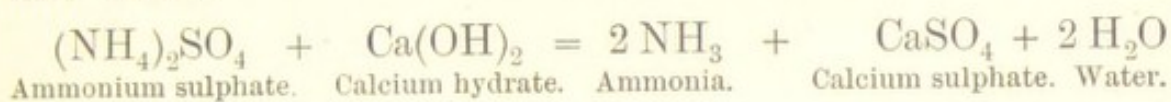
Ammonia (NH₃)

Ammonia in a pure state is a gas, and when dissolved in water is termed the volatile alkali. It is composed of one part of nitrogen and three parts of hydrogen by volume, and can be obtained from vegetable and animal compounds containing nitrogen and hydrogen by natural decomposition or by heating.

Ammonia is produced largely during the manufacture of coal-gas by the destructive distillation of coal, and also from shale during the manufacture of petroleum. In the former case the products of distillation pass through cooled settling tanks containing water, which retain the coal-tar and the ammonia, while the coal-gas passes on. The settling tanks

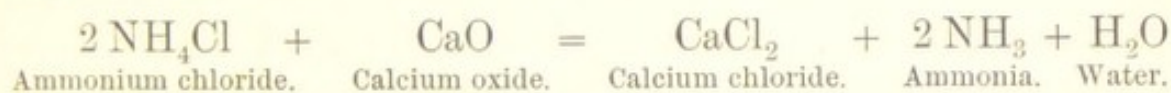
then contain a thick oily lower layer of coal-tar and an upper watery layer of "gas liquor" which contains ammonia partly dissolved in the free state and partly as sulphate, sulphide, and carbonate. The gas liquor is run off and boiled with lime, when ammonia is evolved. The ammonia is led into lead-lined vessels containing sulphuric acid, with which it forms ammonium sulphate, which separates out as a white solid, and is removed by perforated ladles, and forms the crude ammonium sulphate of commerce. This is the source of all ammonium salts in commerce.

The "ammonia solution" of commerce is made by heating ammonium sulphate with caustic soda, or preferably slaked lime (calcium hydrate), which is cheaper, and passing the gas into water.



Experiment 18.—Put into a test-tube a piece of cheese and gently heat. Place a piece of red litmus paper in the mouth of the tube. After a short time the colour is changed to blue, proving the presence of an alkaline gas (ammonia), thus indicating that ammonia can be obtained from cheese.

Experiment 19.—Mix equal quantities of dry sal-ammoniac and powdered oxide of lime, also quite dry. Place the mixture in a flask and put a layer of dry lime on the top. Cork tightly, with a delivery-tube inserted in the cork. Heat gently, and ammonia gas will be evolved, which may be collected by upward displacement; a strip of red litmus paper held at the mouth will become blue when the jar is full. The chemical change may be represented thus:—



This gas, when passed into water, forms the liquid ammonia of commerce. Ammonia gas is remarkably soluble in water, the degree of solubility depending considerably on temperature. "At 0° C. one volume of water dissolves over 1100 volumes of the gas, and at 20° C. over 740 volumes are dissolved. The strongest form of the solution has a specific gravity of .880."

Various Properties of Ammonia

1. It is soluble in water, which greatly increases its usefulness.
2. It is strongly alkaline to litmus.
3. It is a gas and possesses a peculiar pungent odour.
4. It has great cleansing properties and also destroys colour, especially pale shades of pink and blue.

Its Use in Laundry Work

Ammonia is used in laundry work for undyed woollen material. The proportion used depends entirely upon the strength of the ammonia. If the strongest form (.880 Sp. Gr.) is used, one table-spoonful to every two gallons of water is ample; but if an adulterated form is preferred, of which there are plenty in the market, it is necessary to add a larger proportion of the liquid. To prepare the washing water, put a definite quantity of warm water into a tub and add the necessary proportion of ammonia; then add a small quantity of melted soap, just enough to form a slight lather. The flannels should then be pressed well under the water, and the tub covered with a board or cloth to prevent the gas escaping, and left for twenty minutes or half an hour; at the end of that time they are washed as ordinary flannels. The ammonia dissolves the grease in the clothes, and it is marvellous how much dirt separates from the fabric without even squeezing or kneading. It is a most useful cleansing agent, and owing to its volatile property it cannot remain in the fabric, as soap or soda would, to the detriment of the material.

Ammonia solution, or *so-called* "liquid ammonia", owing to this volatile property, must be carefully kept in a glass-stoppered bottle, and at times when the strongest solution is employed it is necessary to fasten the stopper by tying it down, to prevent its being displaced by the strong escaping gas which collects in the upper part of the bottle.

Ammonium carbonate is sometimes used in the washing water for very dirty, greasy, woollen clothes. It is dissolved and used in the washing water as in the method of using soda, but owing to the volatile property of ammonia, especially if

mixed with hot water, it is less injurious than washing soda. The expense of ammonium carbonate as compared with the cost of washing soda renders it less popular as a cleansing agent.

Notes on Lesson on Alkalies

Aims of Lesson—To teach

The different kinds of alkalies used in laundry work.

Their composition.

Their source and manufacture.

Their properties and use in laundry work.

Apparatus—

Specimens of caustic soda, potash, ammonia solution and gas, sodium or potassium, plate, piece of platinum wire, bunsen burner, test-tubes, common salt, sulphuric acid, calcium carbonate, washing soda, sodium sulphate, ammonium sulphate, calcium oxide, potassium chloride, basin and water, red litmus paper, small piece of cheese, cork and delivery-tube, oil, coloured muslin, black-board, easel, chalk, and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show bottles containing caustic soda, potash, and ammonia, also freshly-cut sodium or potassium.	Obs. 1. —The caustic soda and potash are white solids, the ammonia is a gas, and the sodium has a metallic lustre when freshly cut. Sugg. 1. —Soda, potash, and ammonia are called alkalies.	Inf. 1. —Three kinds of alkalies chiefly used in laundry work, two solid and one as a solution of a gas.
Exp. 1. —Place one piece each of caustic soda and potash on a dish and leave exposed to the air for a few minutes, and allow class to smell ammonia.	Obs. 2. —The two solids deliquesce in air, and the ammonia solution has a strong pungent smell. Sugg. 2. —Caustic alkalies combine with the moisture of the air and become liquid. Sugg. 3. —Ammonia in a pure state is a gas with a strong smell; it is also volatile, and very soluble in water, and is prepared in this condition.	Inf. 2. —Caustic alkalies have a strong affinity for water, and must be kept air-tight to prevent absorbing moisture. Inf. 3. —Ammonia used in laundry work is the pure ammonia gas dissolved in water, and is called liquid ammonia.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 2. —Heat a piece of caustic soda in bunsen flame on end of a platinum wire, also a piece of caustic potash.	Obs. 3. —The flame when soda is heated is coloured a rich yellow colour, and potash gives a violet colour. Sugg. 4. —Different metals give differently-coloured flames.	Inf. 4. —The presence of some metals may be detected by the colour they appear when heated in a bunsen flame.
The teacher should here show substances from which caustic soda and potash are obtained and explain manufacture.		
Exp. 3. —Put a piece of sodium on water and test with red litmus.	Obs. 4. —A strong chemical action takes place between the sodium and water, hydrogen gas is evolved, and the sodium melts by the heat of the action; the red litmus becomes blue.	Inf. 5. —The sodium combines with the hydrogen and oxygen of the water, liberating hydrogen, and forms caustic soda in solution.
Exp. 4. —Heat a small piece of cheese in a test-tube, and hold a piece of red litmus paper in the mouth of the tube.	Obs. 5. —Litmus paper becomes blue. Sugg. 5. —Cheese contains nitrogen and hydrogen.	Inf. 6. —Ammonia is obtained from many substances containing nitrogen and hydrogen.
Exp. 5. —Heat a small portion of ammonium chloride in a dry test-tube with red litmus paper near the mouth of the tube.	Obs. 6. —The substance gradually disappears and red litmus is again changed to blue. Sugg. 6. —Ammonium chloride when heated is split up into gases. Ammonia is one of them. Sugg. 7. —Ammonia is obtained on a large scale from ammonium sulphate.	Inf. 7. —The action of the gas upon litmus proves it to be an alkaline gas. Ammonia is the only gaseous alkali. Ammonia of commerce is chiefly obtained from ammonium sulphate.
Exp. 6. —Again, put a small quantity of ammonium sulphate mixed with calcium oxide into test-tube, fasten with cork and delivery-tube and heat; allow the gas evolved to pass into water.	Obs. 7. —The water dissolves the gas, and the liquid turns red litmus blue.	Inf. 8. —Ammonia is soluble in water and imparts its alkaline property to the water.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 7. —Put a small piece of soda and potash in separate test-tubes, add a little water and test with red litmus.	Obs. 8. —Both substances dissolve, and the liquid also changes the colour of red litmus.	Inf. 9. —Soda and potash are also soluble in water and are alkaline to litmus.
Exp. 8. —Add a small portion of soda solution to a mixture of oil and water. Repeat experiment with potash and ammonia.	Obs. 9. —Each of the alkalies acts on the oil and renders it soluble in water. Refer class to lessons on soap and soda.	Inf. 10. —Alkalies are grease solvents and aid greatly in cleansing of clothes.
Exp. 9. —Put a piece of coloured silk into strong caustic soda. Repeat experiment with potash.	Obs. 10. —Fabric and colour are destroyed. Sugg. 8. —Caustic alkalies also burn the skin, but their salts with fatty acids (<i>i.e.</i> soaps) do not act so. Refer to washing soda.	Inf. 11. —Caustic alkalies should never be used in a pure state, but only as their salts with fatty acids as in soaps.

Black-board Summary on Alkalies

Different kinds of alkalies:—

- | | |
|--------------------|-----------|
| 1. Caustic soda, | } solids. |
| 2. Caustic potash, | |
| 3. Ammonia, | } gas. |

Composition:—

1. Sodium, hydrogen, and oxygen.
2. Potassium, hydrogen, and oxygen.
3. Nitrogen and hydrogen.

Source and manufacture:—

Soda is obtained from sodium chloride.

Process:—

1. Sodium chloride + sulphuric acid = sodium sulphate + hydrochloric acid.
2. Sodium sulphate + calcium carbonate = sodium carbonate + calcium sulphate.
3. Sodium carbonate + calcium hydrate = sodium hydrate + calcium carbonate.
4. Potash is obtained from potassium chloride by a similar process.
5. Ammonia is procured from ammonium chloride or sulphate by heating it with calcium oxide.

Properties:—

1. Soluble in water.
2. Alkaline to litmus.
3. Saponify oils and fats, consequently have strong cleansing powers.
4. Neutralize acids forming salts.

Use:—

Ammonia is used in washing to emulsify grease and cleanse clothes. Caustic alkalies are used in soap-making.

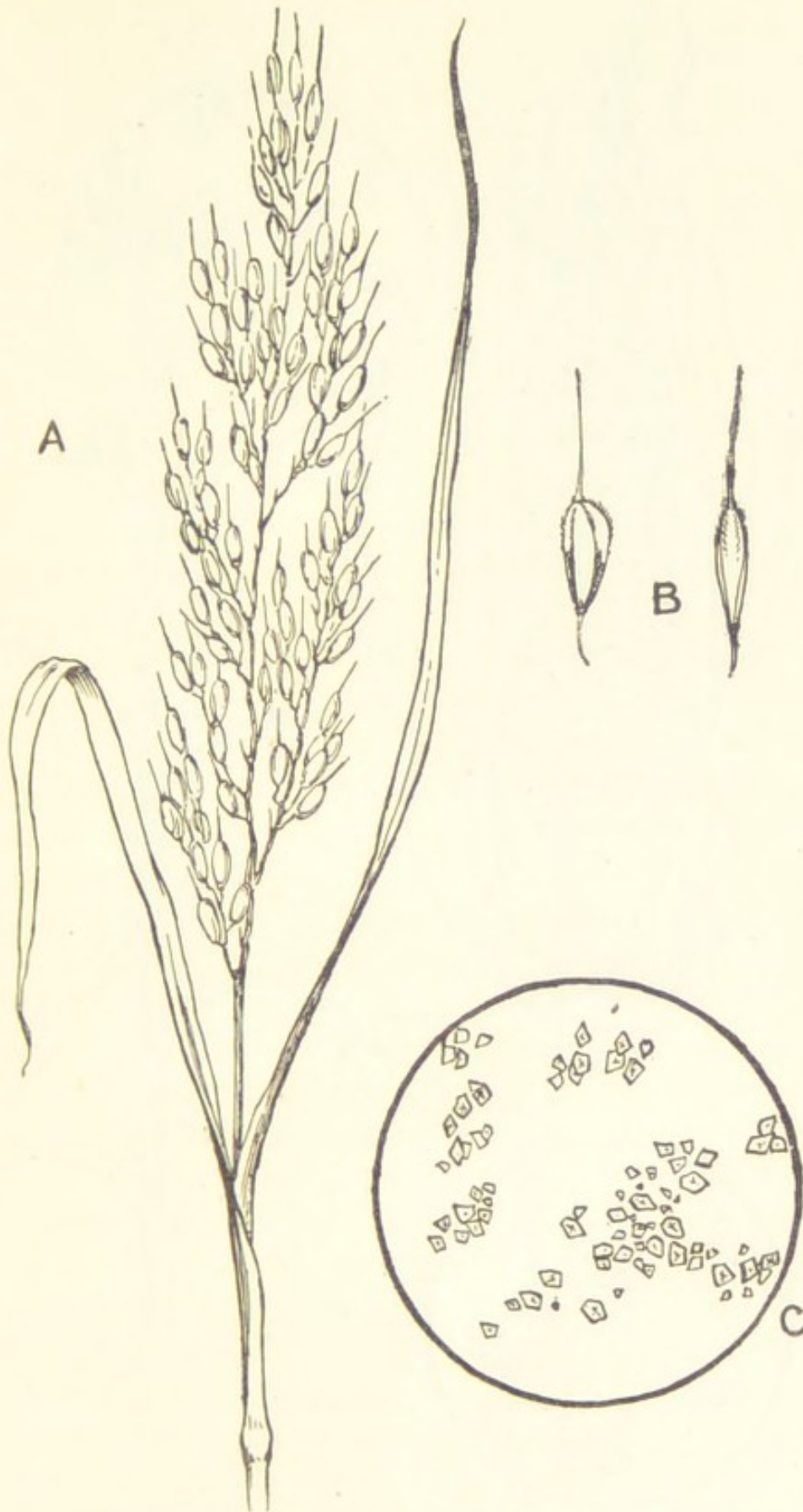
CHAPTER V.—STARCH ($C_6H_{10}O_5$)

Starch is of vegetable origin, and is found in varying proportions in all plants, in the tubers of some, such as potatoes, in the grain of others, and the leaves and stems of all. Rice, wheat, maize, and potatoes are considerably rich in starch, and it is from these substances that the starches for laundry work are chiefly obtained. The approximate proportions of starch found in the above substances are as follows: rice 76 per cent, wheat 71 per cent, maize 65 per cent, potato 20 per cent.

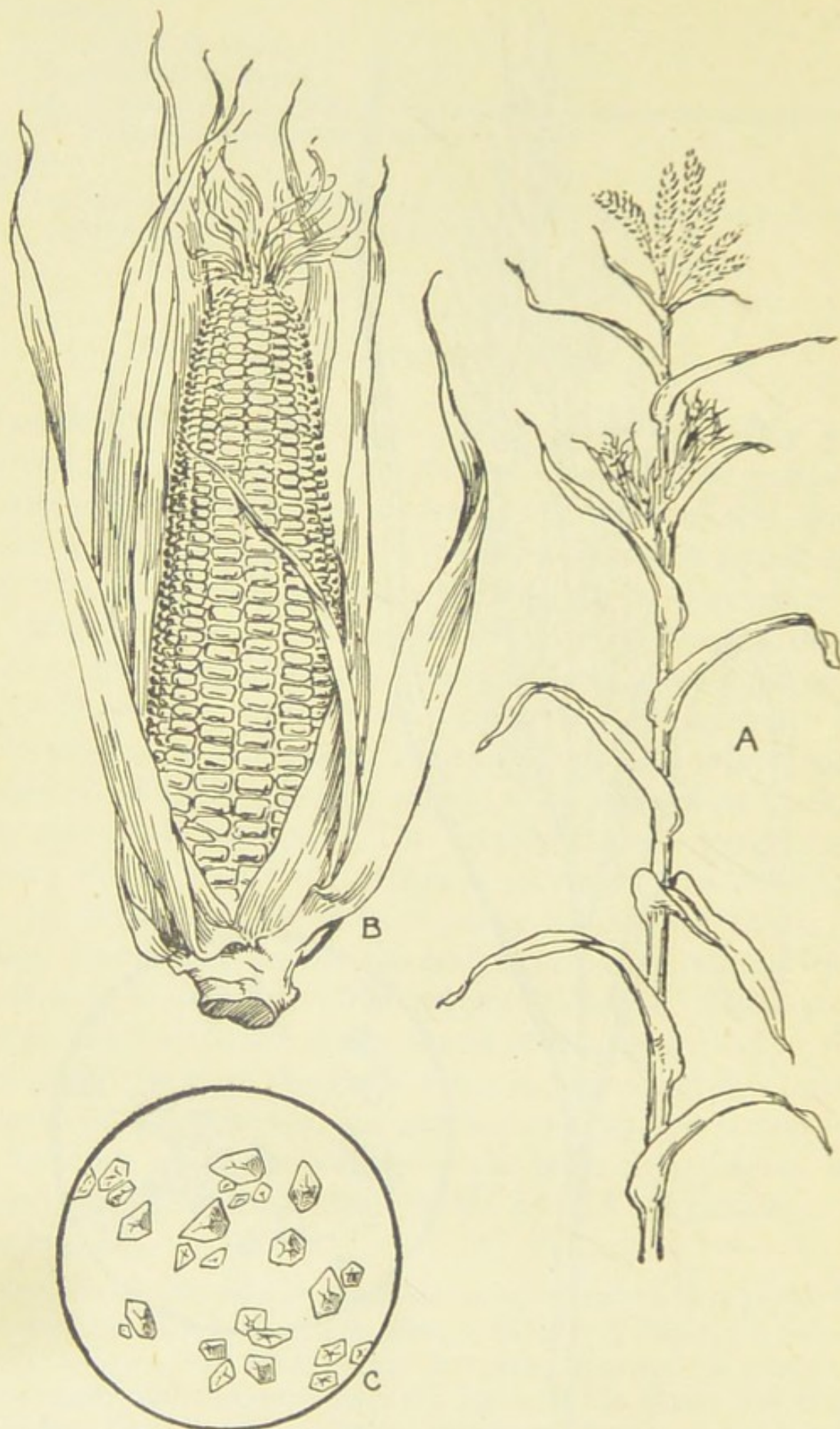
Composition.—Starch in a natural state is a white solid consisting of small granules which are composed of carbon, hydrogen, and oxygen. The hydrogen and oxygen are present in the proportion as found in water; this the plant absorbs chiefly from the soil and partly through the leaves.

The atmospheric carbon dioxide is the chief source from which the plants receive their supply of carbon. The carbon dioxide gas is absorbed by the leaves of the plant; and in the presence of sunshine the green colouring matter of the leaves is enabled to decompose this gas, assimilating the carbon for the building up of the tissues of the plant, and yielding up the oxygen for the purification of the air and the preservation of animal life.

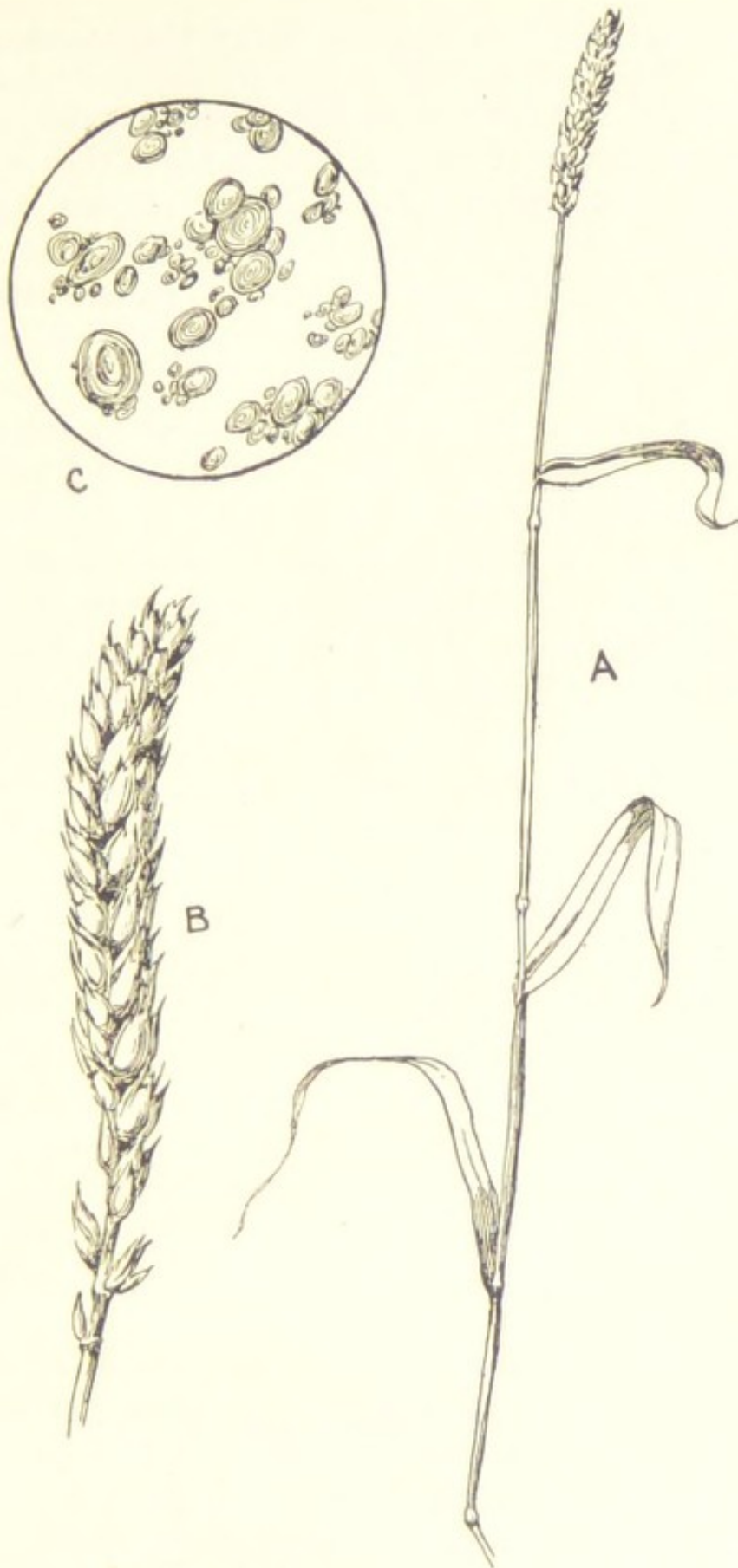
Experiment 20.—Put a small quantity of starch in a perfectly dry test-tube and hold in the bunsen flame. A deposit of water will be seen on the sides of the test-tube, proving the presence of hydrogen and oxygen. Apply a light to the fumes and they will burn, proving that volatile organic substances are evolved; and a black residue remains in the test-tube, which indicates the presence of carbon.



A, Rice Plant. B, Rice Grains. C, Granules of Rice Starch, magnified



A, Maize Plant. B, Head of Indian Corn. C, Granules of Maize Starch, magnified



A, Wheat Plant; B, Head of Wheat. C, Granules of Wheat Starch, magnified

Preparation of Starch from Vegetables

The grain of rice is softened and disintegrated by steeping it in a weak solution of sodium hydrate; it is then washed in pure water, dried, ground, and sifted to remove the gluten or albuminous matter and any fibrous matter. It is again treated with alkaline water to purify it from nitrogenous matter, then with water, after which it is allowed to settle, and then carefully dried and packed.

Wheat and maize starch is also prepared by steeping the grain until it becomes quite soft, then it is mixed with water, and ground between rollers into a soft paste. After which it is left for a few days until fermentation sets in, and removes the sugar present in the grain, and the starch granules are loosened from the gluten. The starch is then passed through revolving cylinders which act as sieves, first with alkaline water to remove any glutinous matter, then with pure water. When the process of purification is completed, it is dried and made ready for the market.

Starch is sometimes prepared from wheat flour by a mechanical process. This is done by making the flour into a stiff paste, and kneading it with water over sieves until all the starch is liberated, after which it is thoroughly washed, and slowly dried.

Potato starch is prepared by shredding the potatoes to pulp. To do this the tubers are placed in a cylindrical machine provided with knives on the inner surface. The cylinder is made to revolve rapidly until the potatoes are reduced to the desired consistency. The mass is washed over sieves under a stream of water, to extract the starch and leave impurities behind as a pulp. The starch is then washed, and in many cases treated with alum and sulphuric acid to purify it, being afterwards thoroughly washed with water, and then dried on porous bricks. Rice starch is considered the best for laundry work, because of the fineness of its grains in comparison with those of other starches. (See illustration.) The minute grains of rice starch enter the fabric more

numerously, and give the material the desired stiffness without making it appear rough on the surface. Other starches, especially if used as cold-water starch, make the fabric too



A, Potato Plant. B, B, Blossoms. C, Potato. D, Granules of Potato Starch, magnified

stiff, and in many cases it is more difficult to obtain a high finish on the surface of the linen.

Test for the Presence of Starch

If starch is present in any solution, one drop of iodine added to a small quantity of the liquid will yield a blue coloration, which will also disappear on heating the liquid, and reappear on quickly cooling under a tap.

Test for Adulteration in Rice Starch

The principal adulterants usually found in rice starch are admixtures of other starches; and as the grains of different starch substances vary considerably in size and shape, their presence can easily be detected by careful microscopic examination. This is one of the most accurate methods for discovering foreign matter in starch.

Properties of Starch

Starch is a white, solid, granular substance, insoluble in cold water; the grains mix freely with the water and are for a time held in suspension, but eventually settle to the bottom, and may be recovered by pouring the water off and exposing the paste to a gentle heat until dry. Starch is partially soluble in hot water, but before it can mix with the hot water it must be previously broken up in a small quantity of cold water to separate the grains. Hot or boiling water poured over dry starch does not break it up sufficiently to expose the grains directly to the intense heat of the water, consequently many of the granules remain unacted upon and appear in the form of lumps in the liquid. When water from 180° to 212° F. or 82° to 100° C. is poured over starch the grains rapidly absorb the water and increase in size until the outside coat or envelope of "starch cellulose" encasing the starch grain bursts, and the "starch granulose" oozes out and becomes soluble in water, and forms with the insoluble cellulose a thick, jelly-like, semi-transparent substance, commonly known as "hot-water starch", or "clear starch". If a portion of the prepared starch is diluted and boiled for a length of time it is rendered soluble, and more especially if the solution is slightly acidulated.

Starch is a neutral substance having no reaction on litmus. It has a great stiffening property, and is in consequence used in laundry work for stiffening different kinds of material. This property varies in degree according to the method of preparing the starch before using. For example, if the starch is cooked by the addition of boiling water before it is used for

stiffening any fabric, the degree of stiffness is much less than when the starch is used in an uncooked state. The grains of cooked starch having increased in size to their full extent, no application afterwards of heat or moisture to the linen will alter appreciably the stiffness already obtained. But when uncooked starch is used, the grains in that state being much smaller enter in larger numbers into the fabric, and by the aid of a hot iron and the water already in the material the grains swell, increasing largely in size, and add considerably to the stiffness of any fabric for which the starch is used.

The Use of Starch in Laundry Work

Starch is used in laundry work for stiffening muslin, lace, linen, and cotton materials. It improves the appearance of clothes, and also enables them to resist the action of dust, and they in consequence keep clean longer than when they are quite limp. The degree of stiffness necessary enables the laundress to decide as to which is the better starch to use (hot- or cold-water). As a rule, it is better to use hot-water starch for muslins, laces, prints, table-linen, and cotton underwear. It not only makes the clothes less stiff and more agreeable to wear or use, but it makes them look clearer than when cold-water starch is used. Except in the case of muslins and print dresses this starch is seldom used in its full strength, but it is diluted to a degree varying according to the quality of material to be starched, and also to the stiffness required. Usually a thin material requires a thicker starch than one of a thicker make. The following may be considered average proportions of hot-water starch to be used for different kinds of material:—Muslins, print blouses and skirts, white or coloured underskirts, babies' robes, and Dutch bonnets are as a rule stiffened in full-strength starch. It is better to starch only the lower two-thirds of underskirts, leaving the upper part soft to cling to the figure. Babies' dresses should always have the bodices less stiff than the skirts. For print pinafores, aprons, muslin handkerchiefs, and common laces,

equal parts of starch and water give a very good stiffness. The starch for table-linen and pillow-slips, if diluted to one-fourth of its strength, gives the necessary degree of stiffness. Frills of pillow-slips are usually starched in thicker starch. Underwear, unless wished specially stiff, is done in starch reduced to about one-fifth of its strength.

It is necessary to use one's common sense in using starch, reducing the strength to suit the quality of the material, remembering that starch varies in strength according to the quantity of water used in its preparation. If in proportion only a small quantity of boiling water has been used to cook the grains, and the starch is thick, it requires more reducing than when a larger quantity of water has been added. The proportions of starch and cold water necessary to mix the starch into a paste must be accurately measured. To every small table-spoonful of starch two full table-spoonfuls of cold water should be added, and both thoroughly mixed together before boiling water is poured over them.

Cold-water starch is used for shirt fronts, collars, and cuffs, large sun-bonnets and sun-hats, or any article that is required very stiff, and for these the starch is used in the proportion of one table-spoonful of starch to half a pint of cold water. This form of starch is used by many people instead of hot-water starch, but the clothes for which it is used are almost invariably less clear in appearance, and as they must be ironed while wet it takes a longer time to do the work.

Notes of Lesson on Starch

Aims of Lesson—To teach

The source of starch.

How it is produced in the plant.

Its composition.

Its manufacture.

Test for starch in substances.

Test for adulteration.

The properties and use of starch.

Apparatus—

Heads of indian corn, wheat, and rice, also a potato. Small quantities of

indian corn, wheat, rice, and potato starch, illustration of grains magnified test-tubes, bunsen burner, cold and boiling water, lime-water, growing plant, piece of muslin, flour, iodine, litmus solution, soda, hot iron and covered board, three basins, duster, chalk, black-board and easel, knife. Specimens of constituents of rice or other vegetables.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show class specimen plants of rice, wheat, indian corn, and potato.	<p>Obs. 1. — The rice, wheat, and maize are different in appearance, but all have seeds growing at top of a stalk. The potato is a hard solid, and appears white when cut in two.</p> <p>Sugg. 1. — Potato is a tuber of the potato plant.</p> <p>Sugg. 2. — Starch may be obtained from all plants, but for laundry work chiefly from these four, as they yield a large quantity.</p>	Inf. 1. — Starch may be obtained from seeds of many plants and from the roots of others.
Illus. 2. — Show different kinds of starch obtained from above plants, and illustrations of grains magnified.	<p>Obs. 2. — Starch is a white powder.</p> <p>Obs. 3. — The grains of each specimen are different in size and shape.</p> <p>Sugg. 3. — The starch composed of the smaller grains is best to use for stiffening linen.</p>	<p>Inf. 2. — The different kinds of starch are similar in appearance until the grains are magnified.</p> <p>Inf. 3. — Rice starch, having the finest grains, is most suitable for laundry work.</p>
Exp. 1. — Put a small quantity of starch into a dry test-tube and heat in the bunsen flame. Apply a light to the fumes.	<p>Obs. 4. — The starch in the tube becomes black, and water is deposited on the sides of the tube.</p> <p>Obs. 5. — Brownish fumes are given off, which burn if a light is applied.</p> <p>Sugg. 4. — There is organic matter in the fumes, which burns.</p>	Inf. 4. — When dry starch is heated, it evolves water and brown fumes, and a black residue of carbon remains in the test-tube. This proves that starch contains hydrogen, oxygen, and carbon.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 2. —Breathe into lime-water contained in test-tube.	Obs. 6. —The water becomes milky. Sugg. 4. —All animals expire carbon dioxide.	Inf. 5. —The atmosphere derives its chief supply of carbon dioxide from the lungs of living beings.
Illus. 3. —Show a green plant growing in moist earth.	Sugg. 5. —Explain that the plants absorb the carbon dioxide from the air, and in the presence of sunlight decompose that gas, assimilating the carbon to build up their tissues and liberate the oxygen. Sugg. 6. —The plant obtains its hydrogen and oxygen from the water that is mixed with the soil, and from the atmosphere.	Inf. 6. —Plants obtain their supply of carbon from the air, and at the same time purify the atmosphere by giving up oxygen.
The teacher should here explain manufacture of starch from different substances, and show samples of constituents of rice, wheat, and maize.		
Exp. 3. —Tie a small quantity of flour in a piece of muslin and squeeze in water.	Obs. 7. —The water becomes milky in appearance. Sugg. 7. —The starch grains pass through the muslin into the water.	Inf. 7. —One method of obtaining starch is by kneading or squeezing wheat flour in water.
Exp. 4. —Shred a potato and mix it with water.	Obs. 8. —The water again becomes milky.	Inf. 8. —Starch is obtained from potatoes by a method similar to that from wheat flour.
Exp. 5. —Boil in separate test-tubes a few grains each of the different starch substances and water, and cool; add to each a drop of iodine.	Obs. 9. —The mixture in each case becomes blue. Sugg. 8. —Iodine gives a blue coloration with any kind of starch. This colour disappears on heating and returns on cooling.	Inf. 9. —Iodine is used as a test for the presence of starch.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 6. —If possible show grains of rice starch under the microscope, and also a mixture of different kinds of starch grains.	Obs. 10. —The grains of rice starch are very small and similar in shape. Obs. 11. —The other grains vary considerably in size and shape. Sugg. 9. —Rice starch is sometimes adulterated with other starches.	Inf. 10. —The microscope is used as a means for discovering adulteration in starch, and is the best method.
Exp. 7. —Mix a small quantity of starch with cold water, and allow it to stand for a short time.	Obs. 12. —The grains of starch float in the water, but eventually settle to the bottom of the vessel, and the water becomes clear as before.	Inf. 11. —Starch is insoluble in cold water.
Exp. 8. —Pour the water off and dry the starch.	Obs. 13. —The starch is similar in appearance to ordinary starch.	Inf. 12. —Mixing in cold water does not materially change starch.
Exp. 9. —Mix a little starch with cold water, and add boiling water.	Obs. 14. —The starch becomes semi-transparent and jelly-like. Sugg. 10. —The insoluble starch cellulose envelope in boiling water has burst, allowing the starch granule to ooze out and dissolve in water, while the insoluble starch cellulose forms an emulsion with the water.	Inf. 13. —The interior of starch granule is soluble in boiling water, the envelope forms an emulsion with the boiling water.
Exp. 10. —Add a drop of red litmus solution and also a little blue litmus solution to a little prepared starch.	Obs. 15. —The starch solution does not change the colour of litmus. Sugg. 11. —Substances that have no reaction on litmus are said to be neutral.	Inf. 14. —Starch is a neutral substance.
Exp. 11. —Dip two pieces of linen, one into hot-water starch and the other into cold-water starch, and dry.	Obs. 16. —The one done in hot-water starch is stiff, and the other is quite limp.	Inf. 15. —Heat is necessary to develop the stiffening property of starch.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 12. — Damp both pieces, and iron with a hot iron.	<p>Obs. 17.—Both pieces of linen are stiff, but the one done in cold-water starch is the stiffer.</p> <p>Sugg. 12.—The grains of raw starch enter more numerous into the fabric, and when cooked make it stiffer.</p>	Inf. 16. —The grains of cold-water starch are cooked in the fabric by the heat of the iron, and thus make the linen stiff.

Black-board Summary

STARCH

Sources of starch:—

Starch is found in all vegetables, that for laundry work chiefly in—

1. Rice.
2. Wheat.
3. Maize.
4. Potatoes.

Composition:—

Carbon, hydrogen, and oxygen.

Manufacture:—

By grinding and mixing with water to separate starch, then purifying, drying, and packing.

Test for presence of starch:—

Iodine gives blue coloration if starch is present.

Test for adulteration:—

Examination of grains under microscope.

Properties:—

1. White solid.
2. Neutral to litmus.
3. Insoluble in cold water.
4. Slightly soluble in boiling water.
5. Stiffening property.

Use in laundry work:—

It is used in varying proportions to stiffen linen and cotton material.

CHAPTER VI.—WASHING BLUES

There are various kinds of blues for use in the laundry. They may be bought either in the solid or liquid form, but the solid blues are more generally used for ordinary household washing.

When these blues are mixed with water, they break up into very fine particles, which are held for a time by the water in suspension, but eventually settle as a fine powder on the bottom of the vessel, proving their insolubility in water.

The liquid blues are not so commonly used. They are usually soluble blues, and chiefly obtained from aniline dyes, consequently the tint given is more permanent, and if used in excess the colour cannot be removed from the clothes unless by the aid of chemicals. The blue in this case acts more as a dye.

Ultramarine, azure, Prussian, and indigo are the solid blues chiefly employed in laundry work. Ultramarine is the most widely used of the four, and for various reasons is the best. It is cheaper than any of the others, and an alkali has no reaction upon it, and also, if properly used, it gives a whiter tint to the clothes.

Ultramarine Blue

Composition.—The ultramarine blue of commerce is of rather a complex nature, and in an average make of the blue, approximate proportions of the following substances may be found.

“Kaolin 50 per cent (this is a form of china-clay, and is composed of the silicates of sodium and aluminium), sodium sulphate 21 per cent, sodium carbonate 17 per cent, sulphur 6, and charcoal 7 per cent.”

Preparation.—The different ingredients are thoroughly mixed, and heated intensely in a furnace from seven to ten hours, air being excluded. When the necessary reaction takes

place the substance is removed, washed, powdered, and dried, and again powdered, and heated a second time with the powdered sulphur added, until the deep-blue colour is obtained. Excess of sulphur, sodium sulphate, or carbonate may be removed by thoroughly washing the blue, when they will dissolve out or float away, and a comparatively pure form of ultramarine blue will settle to the bottom of the vessel. But in many washing blues the impurities mentioned are found largely in excess, and may be termed adulterants.

Azure Blue

Azure blue is seldom if ever used nowadays for laundry work, as it is by far too expensive. It is similar in composition to ultramarine, and is more frequently used as an art colour. It is prepared by reducing the azure stone (lapis lazuli) to a fine powder by beating and mixing with water, when it is treated with dilute acid to remove carbonate of lime. ("Acids do not react upon azure blue as on ultramarine.") The substance is then mixed with linseed-oil, bees'-wax, and turpentine, and washed until the blue separates out as a deposit. This is cleaned, and sold as ultramarine or azure blue.

Prussian Blue

This blue when used gives less satisfaction than any of the others, and for this reason: it is a chemical compound containing iron, and is reacted upon by an alkali such as soda in soap, or by carbonate of soda, which has an alkali reaction, when the iron is thrown down, and forms iron-mould stains on the clothes.

The following experiment will demonstrate this fact:—

Into a small quantity of dissolved ferric chloride add a few drops of potassium ferrocyanide, which will yield a dark-blue precipitate of Prussian blue. Filter and wash the residue with warm water, and put it into a test-tube, and add a small quantity of water. To this add a solution of caustic soda (or washing soda, which will do quite as well). The blue solid is

decomposed, and the result is the formation of a brown precipitate of ferric hydrate and a solution of sodium ferrocyanide.

Thorough rinsing of the clothes is absolutely necessary when this blue is used. If any soap remains in the fabric it decomposes the blue, and the ferric hydrate that is formed leaves the clothes covered with reddish-yellow streaks of iron-mould. Even thorough rinsing does not altogether overcome the difficulty, for the next time the clothes are washed the soap reacts upon the blue that the fabric has retained from the last time of bluing, with a result similar to that described above. This reaction alone is enough to condemn the use of Prussian blue for laundry work.

“Prussian blue is manufactured in large quantities by precipitating yellow prussiate of potash with sulphate of iron, which has been exposed to the air.”

The blue is filtered, thoroughly washed and dried, and sold as a hard solid.

Indigo Blue

Indigo blue is of vegetable origin, and is obtained from the leaves and stems of the indigo plant.

The leaves and stems are covered with water and left to ferment. When fermentation ceases, the liquor is drawn off and violently agitated until the colour is changed, when the indigo separates in the form of solid particles.

Then it is allowed to settle, the sediment is collected, boiled, and filtered. It is then made into shapes and dried.

Indigo blue is more expensive than ultramarine; and if the blue water is too deep in colour it gives a decided greenish-blue tint to the linen, and especially if the clothes are yellow from wearing or bad washing, a greenish tint is obtained to which many people object.

Tests for Different Kinds of Blues

Experiment 21.—To a small quantity of blue water add a weak solution of any acid (vinegar will do). If after a few minutes the colour disappears, the blue present is ultramarine. Alkalies have no action on ultramarine.

Experiment 22.—If an alkaline solution decomposes blue in solution, and yields a reddish-brown precipitate, Prussian blue is present. Acids do not react on Prussian blue.

Indigo is not reacted upon by either dilute acids or alkalies.

Test for Quality of Solid Blues

Mix a given quantity of blue with a small quantity of water, filter, and carefully wash the residue, then allow the water to drain into the filtrate. Slowly dry the blue remaining on the filter-paper. Meanwhile evaporate the filtrate over a gentle heat, and weigh the residue. The weight of the residue in dish equals the amount of soluble impurities in the blue, the character of which may be determined by further testing.

The soluble impurities usually found in ultramarine blue are chiefly sodium carbonate, sodium sulphide, and sodium sulphate.

Experiment 23.—Add a few drops of acid to a portion of the substance. If it effervesces, and a gas is given off which if passed into lime-water yields turbidity, this proves it to be carbon dioxide, and the adulterant to be a carbonate.

Experiment 24.—If a small piece held in the bunsen flame burns with a rich yellow colour, it may be taken for granted that sodium is present. This confirms the fact that sodium carbonate is mixed with washing blue.

Experiment 25.—On the addition of a few drops of acid a gas is given off with a characteristic smell. If this gas is brought into contact with filter-paper moistened with lead-acetate it gives a dark coloration, proving it to be sulphuretted hydrogen, and the impurity to be a sulphide.

The Use of Washing Blues

In the laundry, blues are used to counteract the yellow tint given to clothes by wearing, or by the action of soaps during the washing process.

The blue, reduced to fine particles by mixing it with water, enters the linen in the form of minute grains, and gives linen and calico a uniform tint which intensifies the whiteness of the fabric.

The blue water for white clothes should be of a very pale

shade, the object being to make the clothes white; if the blue water is made too deep in colour they instead become a pale-blue shade, which entirely defeats the object of using blue.

Blue water may also be successfully used for black and blue materials. The water for black and dark shades of blue should be a deep blue; this preserves the colour in both cases—the black from turning brown, and the blue from fading. For light-blue prints the water must be made lighter in colour, and if they are partly white it must be as pale a shade as for white clothes.

Solid blues should always be tied in a bag (preferably flannel); by this means the shade of the water can be easily regulated, and it prevents useless waste of blue.

Points to Remember when Using Blue

(a) Blue water should not be made too deep in colour except for dark materials.

(b) It should not be prepared until it is required. If allowed to stand for a length of time the grains of blue quickly settle to the bottom of the vessel, and the clothes when put into the water become stained by touching the sediment.

(c) Clothes must not be left in the blue water, as the blue would settle on them and make them appear streaky.

(d) The blue bag must be tightly squeezed before putting away; if left saturated it wastes the blue.

Notes of Lesson on Blues

Aims of Lesson—

1. To teach the properties, manufacture, and use of blues used in laundry work.
2. To demonstrate the use of, and bad effects resulting from, abuse of blues.

Apparatus—

Black-board and easel, test-tubes, pieces of different kinds of blue. A few small pieces of linen, soda, vinegar, potassium ferrocyanide, ferric chloride, sodium sulphate, and china-clay. Three small bowls, jug of warm water, chalk, duster and towel.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show class different kinds of blue.	<p>Obs. 1.—Some are solid and others are liquid.</p> <p>Sugg. 1.—Solid blues are more commonly used.</p> <p>Obs. 2.—Solid blues vary in colour—some light, others dark.</p>	<p>Inf. 1.—Solid blues are better for laundry work, and the lighter coloured ones give a paler tint to clothes.</p>
Exp. 1. —Mix a small quantity of each of the solid blues in water, and make class examine.	<p>Obs. 3.—Particles are seen floating about in the water.</p>	<p>Inf. 2.—Solid blues are insoluble in water.</p>
Illus. 2. —Show china-clay and sodium sulphate, sulphur and charcoal.	<p>Sugg. 2.—These substances when mixed and intensely heated result in ultramarine.</p>	<p>Inf. 3.—Ultramarine blue is a chemical compound formed from clay, sodium carbonate, and sodium sulphate, sulphur and carbon. The composition is doubtful.</p>
Exp. 2. —Mix a small quantity of ultramarine blue in water, and add a small quantity of washing soda, then a little acid.	<p>Obs. 4.—(1) The colour of blue does not change when soda is added. (2) The colour entirely disappears when acid is added.</p>	<p>Inf. 4.—Soda has no action on ultramarine blue. Acid destroys the colour.</p>
Exp. 3. —Dissolve a little ferric chloride, and add a few drops of potassium ferrocyanide, and shake.	<p>Obs. 5.—A deep-blue precipitate is produced by mixing the two iron compounds.</p> <p>Sugg. 3.—This deep-blue compound is known as Prussian blue.</p>	<p>Inf. 5.—Prussian blue is a chemical compound containing iron.</p>
Exp. 4. —Put a little of prepared Prussian blue into two test-tubes. Add to one a little washing soda, to the other acid.	<p>Obs. 6.—In No. 1 the blue coloration disappears, and red particles are seen floating about in the liquid.</p> <p>Sugg. 4.—These reddish particles are a compound of iron.</p> <p>Obs. 7.—The colour is not changed when acid is added.</p>	<p>Inf. 6.—Prussian blue is decomposed by soda, and iron is precipitated which would iron-mould clothes; and is in consequence not good for washing purposes.</p> <p>Inf. 7.—Acid has no action on Prussian blue.</p>

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 5. —Mix a small quantity of indigo blue in water in two test-tubes, and add soda to one and acid to the other.	Obs. 8. —The colour does not change in either case. Sugg. 5. —Indigo is largely obtained from a plant known as the indigo plant, but may be also obtained by artificial methods (very complicated process).	Inf. 8. —Soda and acid have no action on indigo blue. Inf. 9. —Indigo blue is of vegetable origin.
Exp. 6. —Dip two pieces of linen into blue water—one into pale-blue, and the other into deep-blue water.	Obs. 9. —The one piece is white, the other is blue.	Inf. 10. —As clothes are required white, pale-blue water should be used to improve the colour.
Exp. 7. —Put the piece of linen out of deep-blue water into a solution of vinegar.	Obs. 10. —The blue colour disappears. Sugg. 6. —The vinegar has decomposed the blue and rendered it colourless. Sugg. 7. —This happens when ultramarine blue is used.	Inf. 11. —If the clothes are made too blue, they ought to be steeped in acidulated water to restore their whiteness.
Exp. 8. —Allow a piece of linen to lie in blue water for a time.	Obs. 11. —The linen is covered with blue patches and streaks.	Inf. 12. —Clothes should not be allowed to lie in blue water, as blue, being a powder, settles on to them, and the tint is uneven.

Black-board Summary

BLUES

Different kinds of blue:—

1. Liquid, usually made from dyes.
2. Solid—
 - Ultramarine.
 - Azure.
 - Prussian.
 - Indigo.

Ultramarine—a chemical compound containing china-clay and sodium sulphate, sodium carbonate, sulphur, and carbon.

Azure is a similar compound.

Prussian—a chemical compound containing iron.

Indigo is of vegetable origin, is obtained from the indigo plant, and also by complicated artificial methods.

Action of soda and acids on blues:—

Ultramarine with soda gives no reaction, consequently is good for washing purposes.

Ultramarine with acid, colour is destroyed.

Prussian blue with soda yields precipitate of iron, which would iron-mould clothes.

Prussian blue with acid, no reaction.

Indigo, no reaction with either alkali or acid.

Use of blue:—

1. Blue is used to improve colour of white, blue, and black clothes.
2. Blue water should be a pale shade for white clothes. Deep shade for blue and black materials.

N.B.—1. Blue water should not be allowed to stand, as blue settles to bottom of vessel, and would stain clothes. 2. Clothes should not be left in blue water for same reason.

CHAPTER VII.—BORAX ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$)

Borax in a pure state is a chemical compound, consisting of sodium, boron, oxygen, and hydrogen. The crystalline form of borax contains a large percentage of water.

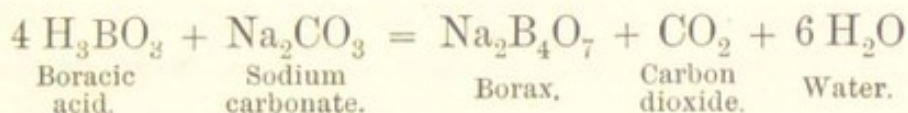
Sources of Borax

Borax is found in large quantities in California, Peru, and on the shores of certain lakes in Tibet, Ceylon, and Tartary, and in Italy and Transylvania. The springs which enter these lakes are charged with borax and other saline substances, and in course of time form large deposits on the bottom and shores of the lakes. These deposits were formerly used as the entire source of the borax of commerce, and were often impregnated with various impurities, and in the case of the crude borax from Asia a kind of fatty substance encrusts it, and adds considerably to the expense of purification.

The purifying process consists of boiling the substance with lime, which combines with the fatty matters to form lime soap, insoluble in water, and may be filtered off. The solution is then concentrated and the borax crystallized out. The high price of borax of this kind, consequent upon the expense of purification, has diminished the demand for it, and has increased

the sale of borax from other available sources, namely the borax lakes in California, which requires less purification. Borax is also prepared on a large scale by heating, in a lead-lined covered vessel, boracic acid and sodium carbonate with steam. The sodium carbonate reacts with the boracic acid to form sodium bi-borate (borax). Carbon dioxide is liberated and also water.

Equation:—



To obtain crystalline borax, the substance is dissolved in hot water and allowed to crystallize.

Test for Composition

The following are simple tests for the qualitative composition of borax:—

Experiment 26.—Put a small quantity of borax on the end of a piece of platinum wire, and hold in the bunsen flame. The flame is coloured yellow, which is the characteristic colour of the sodium flame.

Experiment 27.—Moisten a little borax in a porcelain dish with sulphuric acid; this liberates the boracic acid. Heat over bunsen flame for a time, add alcohol, and apply a light. If boracic acid is present it burns with a green flame; this shows it to be a borate.

Experiment 28.—Place a piece of crystalline borax in a dry test-tube and hold in bunsen flame. Water is driven off, and a white powder remains at the bottom of the test-tube. This shows that it contains water of crystallization.

Test for Presence of Sodium Carbonate

The only adulterant likely to be present is sodium carbonate, owing to its cheapness and its alkaline property.

Experiment 29.—Put a little borax in a test-tube, and add a few drops of sulphuric acid. If effervescence takes place and carbon dioxide is liberated, it proves the presence of a carbonate.

Properties of Borax

Borax in a pure state is a white powder slightly soluble in cold water, but will dissolve to a large extent in boiling water. "Twelve parts by weight of cold water at 20° C. is capable of dissolving one part of borax, while one part by weight of boiling water will dissolve two parts of borax." Hence the reason for dissolving borax before adding it to starch, especially cold-water starch. Borax has an alkaline reaction. If a small piece of red litmus paper is placed in a solution of borax it becomes a blue colour. It has a stiffening property. If a piece of linen is dipped in a solution of borax and ironed, it becomes slightly stiff. Borax also gives a gloss to linen. To obtain the desired result it is frequently put into the starch, but occasionally it is put into the water in which the clothes are boiled. This should only be resorted to in cases where a special gloss is wanted, as so much borax is required to produce effect.

Use of Borax in Laundry Work

Borax is chiefly used in the laundry for giving a gloss to linen. The proportion employed is one table-spoonful to every eight table-spoonfuls of starch. It is at times used for the removal of tea and coffee stains, but if the stain becomes dry before the borax is applied its action is seldom effective, and something stronger has to be used.

Notes of Lesson on Borax

Aims of Lesson—To teach

The sources of borax (natural and chemical).

Its composition and properties.

Its use in laundry work.

Apparatus—

Borax (powdered and crystalline), test-tubes, bunsen burner, platinum wire, sulphuric acid, methylated spirit, matches, boracic acid, cold water, litmus paper (red), two small pieces of linen, iron-holder, hot iron, iron-stand, small basins, covered board, cloth with tea stains.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show specimens of powder and crystalline borax.	<p>Obs. 1.—The one is a white powder, the other is composed of crystals.</p> <p>Sugg. 1.—The powdered borax is stronger, as it has no water in its composition.</p>	Inf. 1.—There are two kinds of borax, powdered and crystalline; powdered borax is the stronger, as it has no water of crystallization, and is, in consequence, more economical.

Teacher should here explain sources and manufacture of borax.

Exp. 1.—Burn a small quantity of borax on end of platinum wire, and refer to same experiment with soap and soda.	Obs. 2.—The flame is coloured deep yellow, as it was when soda and soap were burned.	Inf. 2.—Sodium is one of the constituents of borax.
Exp. 2.—Burn a little boracic acid in bunsen flame.	Obs. 3.—The flame is green in colour.	Inf. 3.—Boracic acid burns with a green flame.
Exp. 3.—Moisten a small quantity of borax with sulphuric acid, and heat for a time; add methylated spirits, and apply a light.	Obs. 4.—The flame of the burning liquid is edged with green.	Inf. 4.—Therefore borax is a <i>salt</i> of boracic acid, and boracic acid is liberated from borax on the addition of an acid stronger.
Exp. 4.—Place a crystal of borax in dry test-tube and heat.	Obs. 5.—The borax melts, and water is deposited on the sides of the tube.	Inf. 5.—The borax melts, and its water of crystallization is driven off.
Exp. 5.—To a small quantity of borax add a few drops of acid.	Sugg. 2.—If effervescence takes place the borax is adulterated with a carbonate.	Inf. 6.—Sodium carbonate is the most common adulterant found in borax.
Exp. 6.—Put a little borax in a test-tube, add cold water, and shake.	Obs. 6.—Borax is only partially dissolved.	Inf. 7.—Borax is slightly soluble in cold water, but soluble to a large extent in boiling water.
Exp. 7.—Hold test-tube in bunsen flame until solution boils.	Obs. 7.—The borax dissolves.	
Exp. 8.—Place a piece of red litmus-paper in borax solution.	Obs. 8.—Litmus paper becomes blue.	Inf. 8.—Borax is a salt with an alkaline property.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 9. —Dip a piece of linen in a solution of borax, and another piece in clean water, and iron both.	Obs. 9. —The piece of linen dipped in borax solution is stiffer than the other, and more glossy.	Inf. 9. —Borax has a slight stiffening property, and helps to give shine to fabric.
Exp. 10. —Place a freshly-made tea stain over a basin, and pour boiling water through.	Obs. 10. —The stain partly disappears.	
Exp. 11. —Rub borax on the stain, and again pour boiling water through.	Obs. 11. —The stain is further removed.	Inf. 10. —Borax aids in the removal of tea stains.

Black-board Summary

BORAX

Sources :—

Borax is found in California, Peru, Tibet, Ceylon, Tartary, Italy, and Transylvania.

It is prepared by heating boracic acid and sodium carbonate together with steam.

Composition :—

Boron, sodium, and oxygen.

Properties :—

Slightly soluble in cold water.

Very soluble in boiling water.

White powder.

Alkaline to litmus.

Slight stiffening and glossing properties.

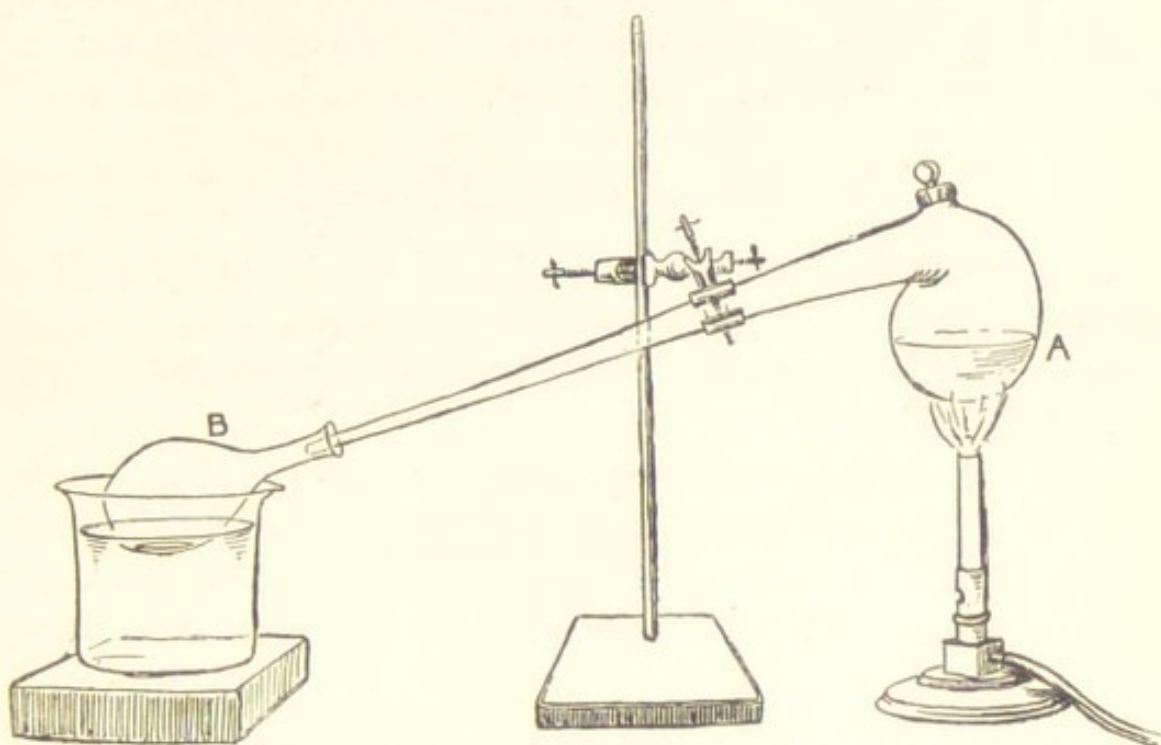
Use in laundry work :—

It is used in starch to give a gloss to linen, and for the removal of stains.

CHAPTER VIII.—ACETIC ACID ($C_2H_4O_2$)

Acetic acid is an organic acid composed of "carbon, hydrogen, and oxygen", and may be produced for experimental purposes by heating sodium acetate with sulphuric acid, when pure acetic acid is evolved, and may be collected in a flask over cold water.

Experiment 30.—Place a small quantity of sodium acetate in a retort and pour a few drops of sulphuric acid over it. Apply a gentle heat. Acetic acid will be driven off and can



Apparatus for Preparation of Acetic Acid

A, Sodium acetate and sulphuric acid; B, acetic acid

be passed into a flask, which must be fitted on to the end of the retort, and rested in a beaker full of cold water.

Acetic Acid from Wood

Commercially, acetic acid is prepared by the destructive distillation of wood. The wood is placed in a closed metal retort and heated intensely, when a brown, tarry liquid is distilled which contains acetic acid. This tarry liquid is boiled, and the vapour evolved is passed into boiling calcium hydrate; the result is the formation of calcium acetate, which is afterwards decomposed by sulphuric acid, and upon being slightly heated, yields acetic acid, which may be collected in a receiver.

Acetic Acid or Vinegar from Wines or Beer

Vinegar is an impure form of acetic acid, and is prepared by exposing (as large a surface as possible) the poorer wines, or beer, to the air. The oxygen of the air is caused to act on

the liquid by means of a minute living organism known as *Mycoderma Aceti*, which has the appearance of a fungus on top of the liquid. The oxygen combines with the alcohol, converting it into acetic acid or vinegar. The mycoderma is said to act here as a "carrier" of oxygen.

Properties of Acetic Acid

1. It neutralizes alkalies. This may be shown by adding carefully acetic acid to a solution of caustic soda coloured blue with litmus, until the litmus becomes neutral in colour.
2. It has a sour taste.
3. It turns blue litmus red, proving that it is acid to litmus.
4. It decomposes carbonates with the evolution of carbon dioxide. If a small quantity of acetic acid is poured over some washing soda (sodium carbonate) effervescence takes place, and carbon dioxide is given off, which if passed into lime-water yields turbidity. This property is useful in washing, as vinegar may be used to counteract the destructive action of washing soda.

The Use of Acetic Acid in Laundry Work

Acetic acid is used in laundry work to neutralize the action of alkaline substances on colours. It also decomposes ultramarine blue, which is one of the most commonly used blues. This property is also valuable in laundry work when the colour of clothes has been destroyed by an excessive use of blue. The original appearance may be restored by steeping them in a weak solution of vinegar.

Notes of Lesson on Acetic Acid

Aims of Lesson—

To teach manufacture and properties of acetic acid, and its use in laundry work.

Apparatus—

Acetic acid, vinegar, sodium acetate, sulphuric acid, retort and stand, beaker and flask, bunsen burner, beer, litmus paper, washing soda, caustic

soda solution, ultramarine blue, black-board, easel, chalk, duster, basins and water.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show class acetic acid, vinegar, sodium acetate, sulphuric acid, and wood.	Obs. 1. —Acetic and sulphuric acids are clear liquids, vinegar is a dark brown. Sodium acetate is a crystalline solid, and wood is a yellowish solid.	
Exp. 1. — Put a small quantity of sodium acetate and sulphuric acid in a retort and gently heat.	Obs. 2. —A clear liquid distils and is collected at the end of retort. It has a sour taste. Sugg. 1. —Acetic acid is prepared on a large scale by heating wood in a retort.	Inf. 1. —Acetic acid is prepared by heating sodium acetate and sulphuric acid. Inf. 2. — Commercial acetic acid is prepared from wood.
Illus. 2. —Show a small quantity of beer and vinegar.	Sugg. 2. —Beer, if allowed to stand exposed to the air, is oxidized into vinegar, a weak and slightly impure solution of acetic acid.	Inf. 3. —Vinegar is obtained from beer.
Exp. 2. —Dip a piece of red litmus paper into acetic acid or vinegar, and taste both liquids.	Obs. 3. —Litmus paper becomes red, and both liquids taste sour.	Inf. 4. —The liquids are acid to litmus, and both have a sour taste.
Exp. 3. —Add carefully acetic acid to a solution of caustic soda, and place litmus in liquid.	Obs. 4. —Litmus paper is neither red nor blue, but neutral in colour.	Inf. 5. —Acetic acid neutralizes alkalies.
Exp. 4. —Add a few drops of acetic acid to a small piece of washing soda.	Obs. 5. —The substances effervesce, and a gas is evolved which turns lime-water turbid.	Inf. 6. —Acetic acid decomposes carbonates, and will overcome the destructive action of washing soda.
Exp. 5. —Make a weak solution of ultramarine blue, and add acetic acid or vinegar.	Obs. 6. —The colour of blue is destroyed. Sugg. 3. —Acetic acid is said to restore colour that has been destroyed by washing.	Inf. 7. —Acetic acid or vinegar decomposes ultramarine blue, and is useful for restoring the colour of white clothes that have been over-blued.

Black-board Summary

ACETIC ACID

Sources:—

Wood, beer and wines, and sodium acetate.

Manufacture:—

By distillation of wood and by heating sodium acetate and sulphuric acid.

By exposing beer and wines to air.

Properties:—

It neutralizes alkalies.

It has a sour taste.

It turns blue litmus red.

It decomposes carbonates with evolution of carbon dioxide.

Its use in laundry work:—

It is used in laundry work to neutralize the action of washing soda, and washing blues.

CHAPTER IX.—OXALIC ACID ($\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$)

Oxalic acid is an organic compound composed of the elements "hydrogen, carbon, and oxygen". Traces of this acid are found in nearly all plants at certain stages of their growth.

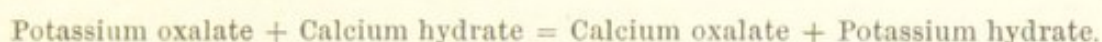
Some organic substances, such as grape and cane sugars, when gently heated with nitric acid yield oxalic acid.

Preparation of Oxalic Acid

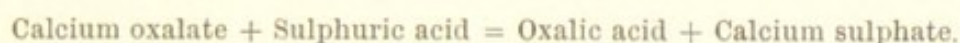
Experiment 31.—Place a given quantity of cane-sugar (50 grammes) in an evaporating basin, cover with strong nitric acid (180 c.c.), and heat gently on a water bath until brown fumes are evolved (this ought to be done in a draught chamber). Leave for a time to cool, and crystals of oxalic acid will separate. These ought to be purified by washing in water, and again allowed to cool and crystallize.

The above method has been commercially superseded by a new process, and the oxalic acid of commerce is now principally prepared from saw-dust, or wood shavings, which are soaked in a solution of caustic potash and heated, resulting

in the formation of potassium oxalate. This is washed and treated with milk of lime, decomposing the potassium oxalate, and calcium oxalate is formed.



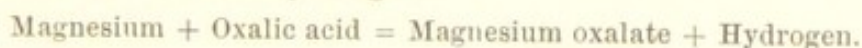
This is also washed and boiled with dilute sulphuric acid, which precipitates the calcium as sulphate, and sets free oxalic acid.



Composition

Experiment 32.—*To demonstrate that carbon, hydrogen, and oxygen are constituents of oxalic acid.* Put a few crystals of oxalic acid in a test-tube, and add a few drops of sulphuric acid, and heat. Pass the fumes into lime-water, which becomes turbid, showing the evolution of carbon dioxide. Apply a lighted taper to the mouth of the test-tube; the evolving gas burns with a pale-blue flame, showing the presence of carbon monoxide. This also shows the presence of carbon.

Experiment 33.—Dissolve some oxalic acid in water, and add a small piece of magnesium ribbon. A colourless gas is evolved which burns with a pale-blue flame, depositing water on a cold surface: therefore it is hydrogen.



Collect the insoluble magnesium oxalate formed, and heat strongly in a porcelain dish. Add a few drops of dilute hydrochloric acid to the residue. An effervescence takes place, and the gas turns lime-water milky. It is carbon dioxide, and therefore oxalic acid contains carbon, hydrogen, and oxygen.

Properties of Oxalic Acid

It is a white crystalline substance and is very poisonous, and ought to be carefully kept and labelled to that effect.

It is acid to litmus and injurious to colour and fabric.

It neutralizes alkalies.

Its Use in Laundry Work

Oxalic acid is used in laundry work to remove old iron-mould stains, but as its action is stronger than salt of lemons,

it is less to be preferred, unless in cases where the stains cannot be removed by the salt. It is also used for washing and bleaching white straw hats.

The method of using oxalic acid is similar to that for salt of lemons, and need not again be explained.

Notes of Lesson on Oxalic Acid

Aims of Lesson—

To teach the sources, manufacture, composition, properties, and the careful use of oxalic acid in laundry work.

Apparatus—

Oxalic acid, sugar, nitric acid, saw-dust or wood shavings, sulphuric acid, lime-water, test-tubes, evaporating basin, magnesium ribbon, matches, bunsen burner, litmus paper, basin, boiling water, material stained with iron-mould. Black-board, easel, chalk, and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show oxalic acid, sugar, and nitric acid.	Obs. 1. — Oxalic acid and sugar are crystalline solids, and nitric acid a clear liquid. Sugg. 1. —Oxalic acid can be obtained from sugar or starch by the action of nitric acid; the method is expensive.	Inf. 1. —Oxalic acid is an organic compound found in certain vegetable substances, especially sugar.
Illus. 2. — Show some wood shavings or saw-dust.	Sugg. 2. —Most of the oxalic acid of commerce is obtained from wood shavings and saw-dust.	Inf. 2. —Oxalic acid is prepared on a large scale from wood.
The teacher should at this stage explain the method of manufacture.		
Exp. 1. — To a given quantity of sugar add dilute nitric acid, and heat for a time, then allow to cool.	Obs. 2. —Brown fumes are evolved; when the substance cools, crystals of oxalic acid are found.	Inf. 3. — Oxalic acid is prepared by heating sugar and nitric acid together.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 2. —Put a few crystals of oxalic acid into a test-tube, and add sulphuric acid and heat; pass fumes into lime-water, and hold a lighted match to the end of tube.	Obs. 3. —Lime-water becomes milky, and a pale-blue flame burns at the mouth of tube. Sugg. 3. —Carbon monoxide burns with a pale-blue flame.	Inf. 4. —Carbon is a constituent of oxalic acid.
Exp. 3. —Dissolve some oxalic acid in water, and add magnesium ribbon, and light the gas at end of tube, and hold flame against a cold surface.	Obs. 4. —Gas burns with a pale-blue flame, and water is deposited on cold surface.	Inf. 5. —Hydrogen is a constituent of oxalic acid.
Exp. 4. —Heat insoluble residue and add to it dilute hydrochloric acid, and pass gas evolved into lime-water.	Obs. 5. —Effervescence takes place, and lime-water becomes milky. Sugg. 4. —The gas is carbon dioxide.	Inf. 6. —Therefore oxalic acid contains carbon, hydrogen, and oxygen.
Exp. 5. —Place an iron-mould stain over a basin and moisten with boiling water, add oxalic acid, and again pour boiling water through.	Obs. 6. —The stain disappears.	Inf. 7. —Oxalic acid acts on iron oxide, and in consequence removes iron-mould stains.

Black-board Summary

OXALIC ACID

Sources:—

Oxalic acid is an organic compound found in several plants, but is obtained chiefly from—

- (a) Sugar.
- (b) Wood.

Composition:—

Hydrogen, oxygen, and carbon.

Manufacture:—

- (a) By adding nitric acid to sugar.
- (b) By soaking wood shavings or saw-dust with caustic potash, and heating strongly, and treating with water. The potassium oxalate formed is precipitated by lime as calcium oxalate, and this with dilute sulphuric acid gives oxalic acid and calcium sulphate (insoluble).

Properties:—

- It is poisonous.
- It is acid to litmus.
- It neutralizes alkalies.
- It is injurious to colour and fabric.

Its use in laundry work:—

- (a) It is used to remove old iron-mould stains.
- (b) It is used for cleaning straw (white) hats.

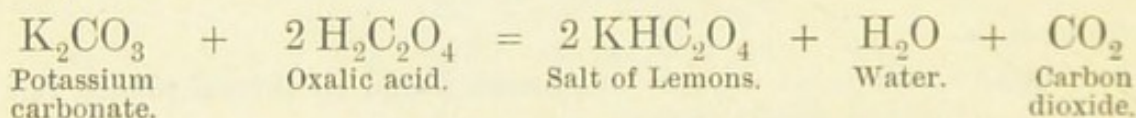
N.B.—Oxalic acid should be labelled poison, and kept beyond the reach of children.

CHAPTER X.—BINOXALATE OF POTASSIUM (SALT OF LEMONS) (KHC_2O_4)

Binoxalate of potassium, commonly known as salt of lemons, is a compound of potassium, hydrogen, carbon, and oxygen.

It used to be, and is still, I believe, in some remote places, manufactured from the leaves and stalks of the sorrel plant. It is generally prepared on a large scale by neutralizing a given quantity of oxalic acid with carbonate of potash, and after neutralization has taken place, as much again acid is added and mixed with the salt. In consequence of this addition of free acid, the salt has an excessive acid reaction.

Equation:



A simple qualitative test for the composition of salt of lemons is as follows:—

Experiment 34.—Dissolve a small quantity of the salt in a clean test-tube, and add a few drops of lime-water, which will yield a white precipitate of calcium oxalate; this is insoluble in acetic acid and ammonia, but soluble in hydrochloric acid. Filter and evaporate the solution; burn a little of the residue, which ought to burn with a violet flame, showing presence of potassium.

Properties of Salt of Lemons

Salt of lemons is a poisonous substance, and ought to be labelled and kept out of the reach of careless people.

It has a strong acid reaction on litmus; it is injurious to light shades of colour, and might also destroy very fine fabric, but has little effect on stronger materials if used in moderation.

It is used in the laundry for the removal of ink and iron-mould stains. The method adopted is the same as that for oxalic acid; but in the case of articles with numerous stains on them, it is better to make a weak solution of the substance and steep the stained clothes for an hour or so, as it is less injurious to expose the whole of the fabric to a solution that is reduced in strength, than to concentrate the chemical on many parts of it; also less time is wasted by this method than by removing each stain separately.

Average proportion of salt of lemons to use for the solution, one-and-a-half table-spoonful to one gallon of boiling water.

To remove Ink and Iron-mould Stains from Coloured Fabric

This can only be done successfully from the darker shades of colour, or from those of fast dyes.

Prepare a solution of binoxalate, one tea-spoonful to a small half pint of boiling water, and have ready for use a basin of cold water. Take each stain separately, twist the fabric tightly behind the stain, and hold it in the solution for a minute or so, then place it in the cold water. This is done to retard the injurious action of the chemical on the colour. Repeat until the stain disappears.

To ensure the successful removal of ink and iron-mould stain from coloured fabric, the greatest care must be taken to prevent the chemical acting on the colour, and this can only be done by careful watching, and frequently changing the material from the chemical bath to the cold water. Salt of sorrel (potassium quadroxalate, $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4 \cdot 2 \text{H}_2\text{O}$) may be used instead of salt of lemons.

Notes of Lesson on Salt of Lemons

Aims of Lesson—

To teach the composition, source, properties, and use of salt of lemons.

Apparatus—

Salt of lemons, oxalic acid, carbonate of potash, lime-water, test-tubes, bunsen burner, platinum wire, calcium oxalate, acetic acid, ammonia, water, hydrochloric acid, litmus paper (blue), piece of coloured muslin (pale shade), piece of calico with stains of ink and iron-mould.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show class salt of lemons, oxalic acid, and carbonate of potash.	Obs. 1. —Salt of lemons and carbonate of potash are white powders, oxalic acid is crystalline in form.	Inf. 1. —Salt of lemons is a salt obtained from an acid and an alkali.
Exp. 1. — Mix some calcium oxalate with water, and add a few drops of acetic acid to one portion, and ammonia to another quantity of the liquid.	Obs. 2. —The mixture is milky in appearance, and does not become clear when acetic acid or ammonia is added.	Inf. 2. —Calcium oxalate is insoluble in acetic acid and ammonia.
Exp. 2. — Pour a few drops of hydrochloric acid into a third portion of the liquid.	Obs. 3. —The white precipitate disappears.	Inf. 3. —Calcium oxalate is soluble in hydrochloric acid.
Exp. 3. — Dissolve a small quantity of salt of lemons in a clear test-tube, and add lime-water.	Obs. 4. —A white precipitate is formed.	
Exp. 4. — Put a small quantity of the solution into three test-tubes; to one add a few drops of acetic acid, to another ammonia, and to a third hydrochloric acid.	Obs. 5. —The precipitate is insoluble in acetic acid and ammonia, but soluble in hydrochloric acid.	Inf. 4. — As the result of these tests is similar to that for calcium oxalate, a similar substance must have been present in the solution.
Exp. 5. —Heat a small piece of salt of lemons in the bunsen flame.	Obs. 6. —Violet flame coloration.	Inf. 5. — Potassium is present in salt of lemons.
Exp. 6. — Dissolve a small quantity in a test-tube, and dip blue litmus paper in solution.	Obs. 7. —Litmus paper becomes red.	Inf. 6. —Salt of lemon is acid to litmus.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 7. —Place a piece of pale coloured muslin in solution.	Obs. 8. —Colour is partly destroyed.	Inf. 7. —Salt of lemons is injurious to colour.
Exp. 8. —Place a piece of material stained with iron-mould and ink over a basin, and pour boiling water through, apply salt of lemons, and again pour boiling water through.	Obs. 9. —The stains disappear.	Inf. 8. —Salt of lemons removes iron-mould and ink stains.

Black-board Summary

SALT OF LEMONS

Source:—

1. Manufactured from leaves of sorrel plant.
2. By neutralizing oxalic acid with potassium carbonate, then adding as much again acid.

Composition:—

Carbon, potassium, hydrogen, and oxygen.

Properties:—

1. It is poisonous.
2. It has an acid reaction on litmus.
3. It destroys colour.

Use in laundry work:—

To remove ink and iron-mould stains.

CHAPTER XI.—SODIUM CHLORIDE (NaCl) (COMMON SALT)

Sodium chloride is chiefly obtained from sea-water and from rock-salt. Salt is prepared from sea-water in large quantities on the Continent, as the climate is so dry and hot, and the evaporation of the water takes place rapidly.

The principal rock-salt districts are the Carpathians, Austrian and Bavarian Alps, Germany, and different parts of the Swiss Alps, and the British salt districts, *e.g.* Cheshire.

Composition

Common salt is composed of sodium and chlorine. To liberate the chlorine from the compound, the following experiment is employed:—

Experiment 35.—(a) Put equal quantities of salt, manganese dioxide, and sulphuric acid into a test-tube and gently heat—chlorine, which is a greenish-yellow gas, and which bleaches wet litmus paper, will be evolved.

(b) Burn a small quantity of salt in bunsen flame—result, rich yellow colour, characteristic of sodium.

Properties of Common Salt

It is a white crystalline solid with a very salt taste, and soluble in water. It renders soap insoluble in water, and fixes colour in clothes. It is almost as soluble in cold as in hot water.

Its Use in Laundry Work

Salt is used in laundry work to fix colours that have softened and run in the washing water. It is said to act as a mordant, and makes the dye bite the fabric, and so prevents its running. Salt cannot possibly be used in the washing water, as it has the power of throwing the soap out of solution, and would render the cleansing of clothes impossible. It is usually put in the rinsing water, which ought to be made rather salt, a good handful of salt to a gallon of water is an average proportion. Salt has a certain cleansing power, and is often used in conjunction with dry soap for the cleansing of pulp basins. The two substances are mixed and rubbed on the dirty parts with a damp cloth, and the basin afterwards washed with warm water and thoroughly dried.

Notes of Lesson on Sodium Chloride (Common Salt)

Aims of Lesson—

To teach the source, composition, properties, and use of common salt in laundry work.

Apparatus—

Salt, and a piece of rock-salt, manganese dioxide, sulphuric acid, test-tube, cylinder, other fittings, bunsen burner, water, soap, a few glass dishes, black-board, easel, chalk and duster, litmus paper, piece of coloured material.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show class common salt and a piece of rock-salt.	Obs. 1. —Common salt is composed of small white crystals; the rock-salt is a hard crystalline solid. Sugg. 1. —Common salt is obtained by evaporation of sea-water, and by conversion of rock-salt into brine, which is pumped up and evaporated.	Inf. 1. — Common salt is obtained from sea-water and from rock-salt.
Exp. 1. — Mix equal quantities of salt, manganese dioxide, and strong sulphuric acid in a test-tube, and heat gently, and hold a piece of coloured moist material in the gas evolved.	Obs. 2. — A greenish-yellow gas is evolved, with a disagreeable smell and bleaching properties. Sugg. 2. —The above-mentioned properties are peculiar to chlorine.	Inf. 2. — Chlorine is a constituent of common salt.
Exp. 2. — Heat salt in bunsen flame.	Obs. 3. —The flame is coloured yellow.	Inf. 3. —Sodium is a constituent of common salt.
Exp. 3. —Add salt to a small quantity of soap lather.	Obs. 4. —The soap rises to the top.	Inf. 4. —Soap is insoluble in salt water.
Exp. 4. —Dip a piece of coloured material into hot soapy water.	Obs. 5. — The colour runs.	Inf. 5. — Soap and hot water make colours run.
Exp. 5. — Squeeze the fabric out, and place in salt water.	Obs. 6. —The colour does not come out to the same extent.	Inf. 6. —Salt in water fixes colour.

Black-board Summary

SALT

Source:—

Sea-water and rock-salt.

Composition:—

Contains sodium and chlorine.

Properties:—

A white solid with a salt taste, soluble in water. It renders soap insoluble in water, and fixes colour in clothes, and has a cleansing property.

Its use in laundry work:—

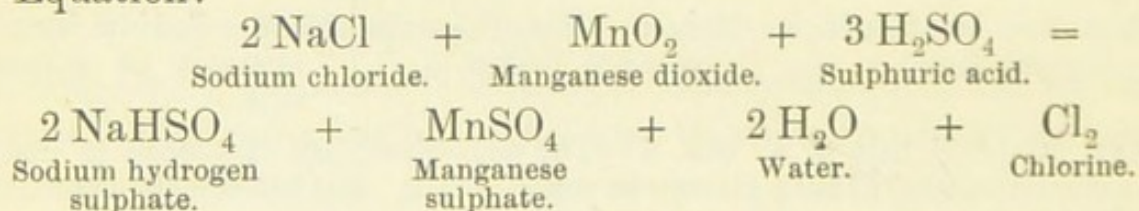
It is used in laundry work to fix colour in clothes, and to cleanse pulp basins.

CHAPTER XII.—CHLORINE (Cl_2)

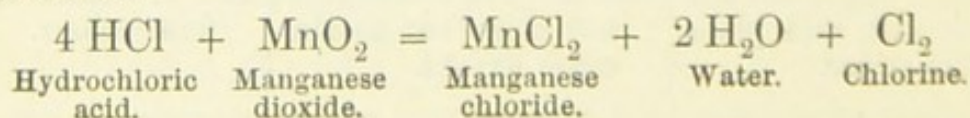
Chlorine is a greenish-yellow gas, and is not found in nature uncombined, but frequently in combination with other substances. One of the most common forms in which it occurs is sodium chloride (common salt). It is from this compound and from hydrochloric acid that chlorine is chiefly obtained, and may be prepared as follows:—

Experiment 36.—In a flask, fitted up with delivery-tube and thistle-funnel, mix equal quantities of common salt (NaCl), manganese dioxide (MnO_2), and strong sulphuric acid (H_2SO_4), and apply gentle heat. Chlorine gas is rapidly evolved, and may be collected in cylinders or dissolved in water. One volume of water is capable of dissolving two volumes of the gas.

Equation:

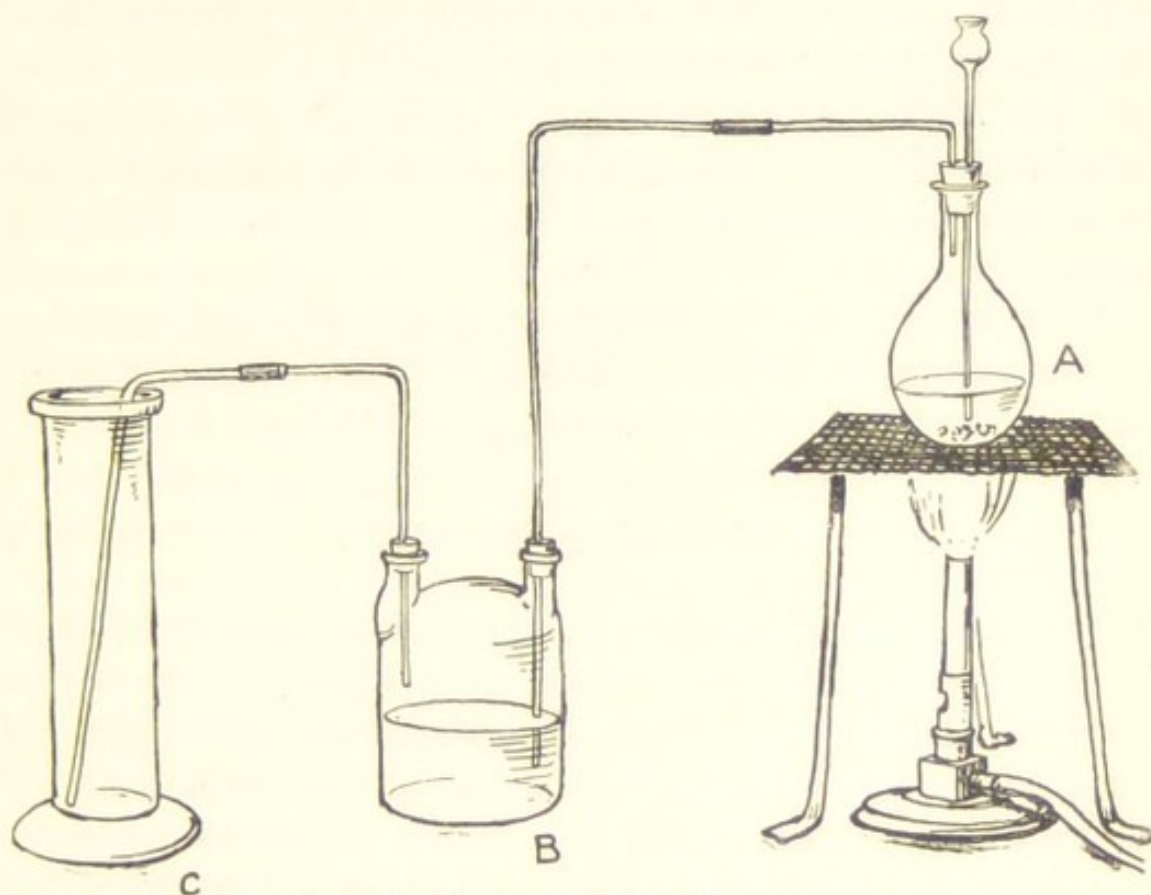


Experiment 37.—Place a small quantity of manganese dioxide in a flask and add hydrochloric acid to form a thin paste, then heat the mixture, and chlorine gas will be given off. The change is as follows:—



This is one of the methods employed for the preparation of chlorine on a large scale for the manufacture of bleaching-powder.

Another process for the manufacture of chlorine for the same purpose, is done by mixing hydrochloric acid gas with air, and passing them over heated bricks saturated with copper sulphate. The gas is decomposed, the hydrogen of



Apparatus for Preparation of Chlorine Gas

A, Vessel containing common salt, manganese dioxide and acid; B, vessel to wash the chlorine gas; C, cylinder of chlorine gas.

which combines with the oxygen of the air, forming water, and the chlorine is set free. The hydrochloric acid gas is usually obtained as a by-product during the manufacture of soda by the Leblanc process.

The electrolytic process is now commercially much used, chlorine being obtained as one of the products of electrolysis of sodium chloride.

Properties of Chlorine

It is a greenish-yellow gas with a disagreeable smell.

It is soluble in cold water, only slightly soluble in hot water. One volume of cold water at 20° C. dissolves two volumes of the gas, which imparts to the water many of its properties.

It destroys colour in *wet* fabrics, and is also a strong disinfectant. Both of these properties are said to be due to its power of decomposing hydrogen compounds, such as water, combining with the hydrogen and liberating oxygen, "which in a nascent state oxidizes colouring matter, rendering it colourless".

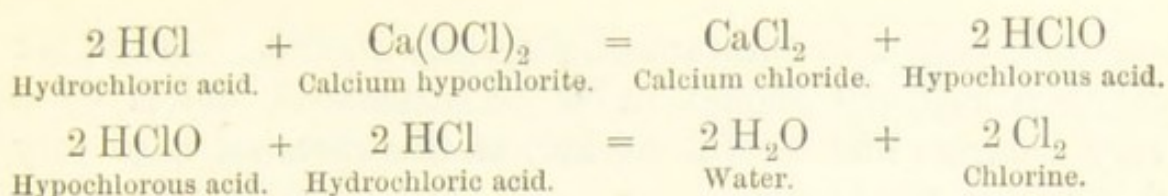
As a disinfectant it oxidizes the germs of disease, and is in consequence largely used for this purpose. (See Appendix for Chlorine Gas as a Disinfectant, page 141.)

Bleaching-Powder

To prepare bleaching-powder, slaked lime (calcium hydrate) is spread upon floors to the thickness of about two inches, and the chlorine gas from the generator is led into the lime, which rapidly absorbs it, forming a compound, known as bleaching-powder, a solution of which contains calcium chloride and calcium hypochlorite, and is known as bleaching-liquor.

The powder is sold to the public as "chlorinated lime", but is more commonly known as "chloride of lime".

It is used largely in bleach-works for the bleaching of calico and linen, and is usually employed in conjunction with an acid, either hydrochloric or sulphuric acid. The cloth is first immersed in the lime bath, and then transferred to the acid solution, which is very dilute. The hydrochloric acid acts upon the hypochlorite constituent, decomposing it, setting free chlorine, which does the work of bleaching; or if very dilute sulphuric acid is used, hypochlorous acid is liberated, and does the work of bleaching.



How to Prepare and Use Bleaching-Liquid

Whether bleaching-powder is to be used as a bleaching agent or for disinfecting purposes, it is better to dissolve it in water, and remove it from the insoluble lime; when in conjunction with the lime its strength is so great that immediately it touches any fabric it burns, and eventually holes appear where the lime has settled. For ordinary laundry purposes half a pound of "chlorinated lime" should be dissolved in half a gallon of water, carefully strained, bottled, and kept for use.

This solution, before being used for bleaching purposes, must be diluted in six times its bulk of water. It ought to be kept in a dark place; if exposed to sunlight, the dissolved bleaching-powder decomposes. The use of this solution should be confined chiefly to the removal of certain stains, as the bleaching action is so strong; and as it is destructive to fabric, it is not advisable to use it for bleaching clothes unless in extreme cases. When removing stains, the stained part only should be put into the liquid and carefully watched, and immediately the stain disappears the fabric must be removed and put into cold water to check the action of the chemical, and prevent burning of the material.

For disinfecting clothes the solution requires to be somewhat stronger than for bleaching, and the liquid is better diluted by four times its bulk of water, or three ounces of bleaching-powder may be carefully mixed with one gallon of water and strained to remove all traces of lime; the clothes may then be put into it and kept for an hour or longer.

Bleaching liquid may be used successfully for tea, coffee, fruit, wine, and mildew stains, and also for most dyes. It may also be used for the removal of stains from coloured

material, except in the case of very pale shades. Its use for coloured material should never be attempted, unless by a very accurate and careful worker, as this chemical is so very destructive to colours.

To remove stains from coloured material a process termed "nursing of the fabric" by professional bleachers is adopted, and is similar to that described for the removal of stains from coloured material by salt of lemons.

Notes of Lesson on Chlorine

Aims of Lesson—

To teach the sources, manufacture, properties, and careful use of chlorine.

Apparatus—

Common salt, manganese dioxide, sulphuric acid, Woulfe bottle or flask and fittings, a few cylinders, test-tubes, hydrochloric acid, bunsen burner, bleaching-powder, water, basins, pieces of coloured calico. Calico with various stains on it. Black-board, easel, chalk, and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Place a small quantity of common salt and manganese dioxide in a test-tube or Woulfe bottle, and add a little strong sulphuric acid, and gently heat.	Obs. 1. —Strong-smelling greenish-yellow gas is evolved. Sugg. 1. —Chlorine is a greenish-yellow gas with a disagreeable smell.	Inf. 1. —Chlorine is obtained from common salt.
Exp. 2. —Mix a small quantity of manganese dioxide with hydrochloric acid and gently heat.	Obs. 2. —A similar gas is given off.	Inf. 2. —Chlorine is also obtained from hydrochloric acid.
The teacher should here explain manufacture of chlorine on a large scale, and of bleaching-powder.		
Illus. 1. —Show bleaching-powder.	Obs. 3. —The powder is grayish in appearance, and has a smell somewhat like that of chlorine.	Inf. 3. —There is chlorine in bleaching-powder.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 3. —Mix a small quantity of bleaching-powder with water, and leave for a time until the lime settles. Add a few drops of hydrochloric acid.	Obs. 4. —Solution is clear. Obs. 5. —It becomes yellow on addition of the acid, and has an odour of chlorine.	
Exp. 4. —Place a piece of moistened coloured rag in jar of chlorine gas obtained in experiment.	Obs. 6. —The colour is entirely destroyed, also the fabric.	Inf. 4. —Chlorine has strong bleaching properties, and it also destroys fabric.
Exp. 5. —Steep a piece of coloured calico in a solution of bleaching-liquid, and also in a solution of chlorine gas.	Obs. 7. —The colour is destroyed, but the fabric is not much impaired. Sugg. 2. —Chlorine is more soluble in cold water than hot.	Inf. 5. —Chlorine in solution is less destructive than chlorine gas.

The teacher should here explain the action and use of chlorine as a disinfectant.

Exp. 6. —Prepare a bleaching solution by mixing $\frac{1}{4}$ lb. of bleaching-powder with one quart of water, and strain. Then dilute with four times its bulk of water.	Sugg. 3. —This is the strongest solution that should be used for bleaching or stain-removing.	Inf. 6. —Solution must be diluted or it will destroy fabric.
Exp. 7. —Steep a piece of calico stained with tea, coffee, fruit, wine, or dye in bleaching-solution.	Obs. 8. —Stain disappears.	Inf. 7. —Bleaching-liquid solution removes various stains.

Black-board Summary

CHLORINE

Sources:—

1. Common salt (sodium chloride).
2. Hydrochloric acid.

Manufacture:—

1. By mixing common salt, manganese dioxide, and sulphuric acid, and heating, chlorine is evolved.
2. By mixing hydrochloric acid, manganese dioxide, and heating, chlorine is evolved.

Properties:—

1. Greenish-yellow gas.
2. Suffocating smell.
3. Soluble in water.
4. Destroys colour (when wet) and fabric.

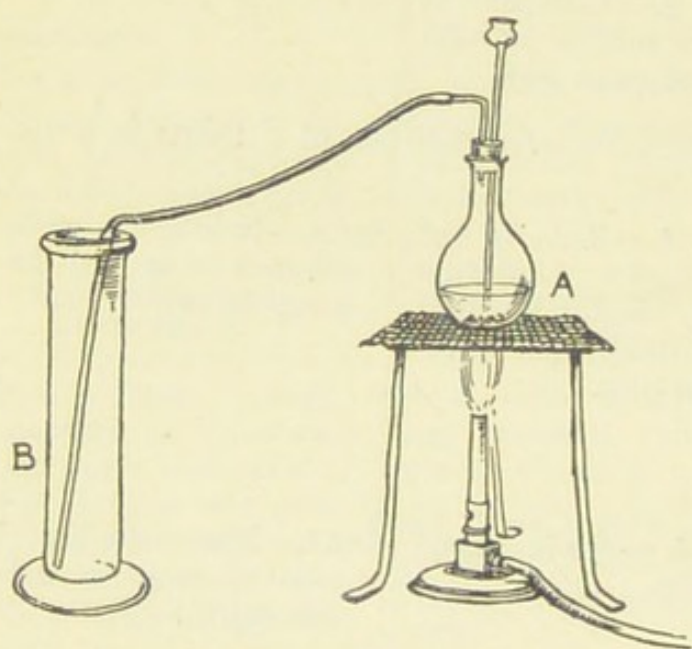
Use in laundry work:—

It removes stains of tea, coffee, fruit, wine, and dyes.

N.B.—Chlorine must be carefully used, as it destroys colour and fabric.

CHAPTER XIII.—SULPHUR DIOXIDE (SO_2)

Sulphur dioxide is composed of sulphur and oxygen, and is prepared by burning sulphur in air or in oxygen gas. It is



Apparatus for Preparation of Sulphur Dioxide
A, Copper turnings and sulphuric acid; B, cylinder of sulphur dioxide

usually prepared on a large scale by roasting in a current of air an iron compound of sulphur, such as iron pyrites (FeS_2), when large volumes of the gas are obtained; but for ordinary bleaching or disinfecting purposes the burning of sulphur in air is usually the method adopted.

For experimental purposes, sulphur dioxide may be pre-

pared by adding concentrated sulphuric acid to copper turnings, and heating the mixture.

Experiment 38.—Put into a flask some copper turnings, and add carefully, through a thistle-funnel, concentrated sulphuric acid, and gently heat. Sulphur dioxide will be evolved, and may be collected by downward displacements. A few cylinders of the gas may be collected, and used to illustrate certain of its properties.

Equation:



Properties of Sulphur Dioxide

It is very soluble in water. "One volume of water at 0° C. absorbs forty volumes of the gas, and one volume of water at 16° C. absorbs forty-two volumes of sulphur dioxide." The solution is known as sulphurous acid.

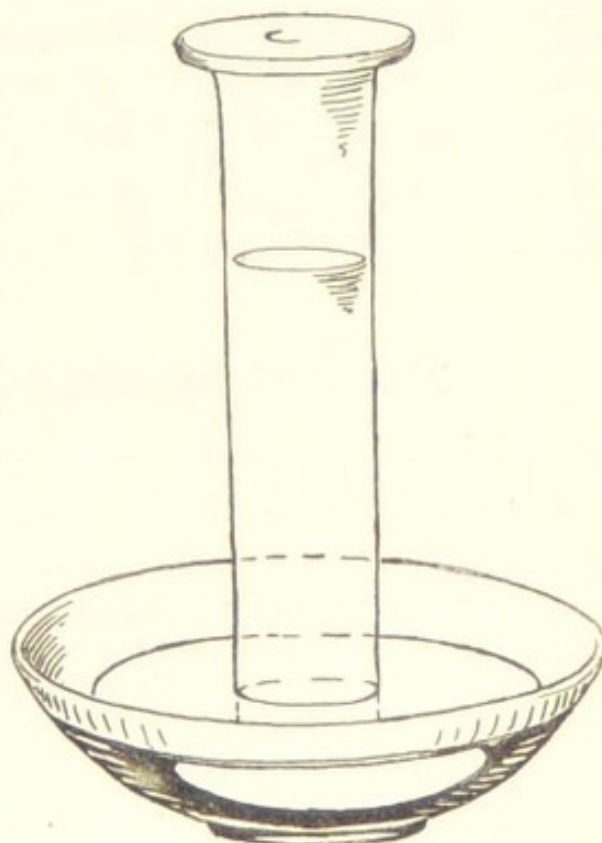
It is acid to litmus. This may be indicated by adding a few drops of blue litmus solution to one of the jars containing the gas, when the colour is changed to red.

It has a strong bleaching action; a few flowers, if introduced into a jar of the gas, will in a few minutes lose their colour. Sulphur dioxide is a powerful disinfectant, and is used for fumigating rooms after cases of infectious diseases.

It is also used for bleaching silk and woollen material, and white straw, and as an "antichlor", to remove excess of chlorine from bleached fabric.

"Its action in bleaching and disinfecting depends on its power of decomposing water, combining with the oxygen and setting free 'nascent hydrogen' which acts as a reducing agent, depriving coloured matter of its colour."

As in the case of chlorine, water is an absolute necessity for the above reaction, and all fabrics to be treated must be



Apparatus showing Solubility of Sulphur Dioxide

thoroughly moistened before being submitted to the fumes. In some cases, however, the sulphur dioxide acts by directly combining with the fabric, and is likely to injure the fibres.

To use sulphur for bleaching and disinfecting, the walls and furniture must be made wet, and all clothing moistened and suspended from lines in the room, and all cupboard doors left open. The sulphur should be put in an iron vessel, and placed over another vessel containing water, and a light applied to the sulphur. The doors and windows should then be fastened and made air-tight for twenty-four hours, when they should be thrown open and left for another day and night. The walls should then be stripped and lime-washed; furniture and washing clothes should be cleaned with carbolic soap. For bleaching, the fabric is placed in an air-tight chamber, and the fumes allowed to act upon the colouring matter for at least twelve hours, when it is removed, rinsed, and dried. 3 lbs. of sulphur will disinfect 1000 cubic feet of space.

Notes of Lesson on Sulphur Dioxide

Aims of Lesson—

To teach the sources, manufacture, properties, and use of sulphur dioxide.

Apparatus—

A piece of sulphur and a piece of iron pyrites, a flask and fittings, copper turnings, sulphuric acid, jars for collecting gas, a few flowers, litmus solution, water, basin, black-board, easel, chalk and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show a piece of sulphur, and if possible a piece of pyrites.	Obs. 1. —The sulphur is a yellow solid, and the other a dark rock. Sugg. 1. —When these are burned, sulphurous fumes are given off.	Inf. 1. —Sulphurous acid gas is obtained by burning these two substances in air.

The teacher should here explain the method of producing the gas from the above substances.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Put into a flask, fitted with a delivery-tube and thistle-funnel, a few copper turnings and strong sulphuric acid, and collect a few jars of the gas.	Obs. 2. —A strong-smelling gas is evolved. Sugg. 2. —This gas is known as sulphur dioxide.	Inf. 2. —Copper decomposes the sulphuric acid, and sulphur dioxide is given off.
Exp. 2. —Place a small bunch of wet flowers into a jar of the gas.	Obs. 3. —The colour of the flowers is destroyed.	Inf. 3. —Sulphur dioxide bleaches vegetable colouring matter.
Exp. 3. —To another jar of the gas add a few drops of blue litmus solution.	Obs. 4. —The colour is changed to red.	Inf. 4. —Sulphur dioxide is an acid gas.
Exp. 4. —Collect a dry test-tube or jarful of the gas, and invert it in a basin of water.	Obs. 5. —The water gradually rises up in the test-tube, especially if the jar be gently shaken occasionally.	Inf. 5. —The gas is soluble in water.

The teacher should here explain the action of sulphur dioxide as a disinfectant, and the method adopted for disinfecting and bleaching.

Black-board Summary

SULPHUR DIOXIDE

Source:—

1. Sulphur.
2. Iron pyrites.
3. Copper turnings and sulphuric acid.

Manufacture:—

1. By burning sulphur, or roasting iron pyrites in air.
2. The decomposition of sulphuric acid by copper.

Properties:—

1. It is soluble in water.
2. It possesses a pungent, suffocating odour.
3. It is acid to litmus.
4. It destroys colouring matter.
5. It has powerful disinfecting properties.

Its Use:—

It is used for bleaching wool, silk, and straw, and for neutralizing the effects of chlorine in fabric, also for disinfecting rooms and clothing after cases of infectious diseases.

CHAPTER XIV.—DIFFERENT DISINFECTANTS

The principal object of disinfecting is the complete destruction of all germs of infectious diseases, and if possible to have this done before the clothing, or any material used by the infected persons, comes into contact with that of healthy people.

To obtain this result, some specialists advise the complete destruction by burning of all clothing, bedding, and other materials used by people suffering from some of the well-known infectious diseases, such as consumption and small-pox.

But many of the people afflicted by these diseases are so poor, that unless compensation is given, they could not afford to have their goods totally destroyed. A substance must therefore be used strong enough to kill the germs, and not to act destructively upon the fabric.

The following substances are a few of the best disinfectants known at the present time: "(1) Extreme heat; (2) corrosive sublimate; (3) formic aldehyde; (4) carbolic acid; (5) sulphur dioxide; (6) chlorine".

Extreme heat may either be in the form of boiling water, or saturated steam under pressure.

Boiling.—Clothes submitted to a temperature of 212° F. or 100° C. for about an hour three days in succession ought to be completely purified.

Fully-developed germs cannot resist for any length of time a temperature of 212° F. or 100° C., and are likely to be killed the first time of boiling; "but the spores, which are more resistant, have to be given time to develop before the boiling is repeated, thus an interval of one night is sometimes allowed between each process of boiling, which is ample time for their development, and the third time of boiling ought to sterilize the material". If the solution in which the clothes are boiled is rendered alkaline by the use of soap or soda, the temperature may be considerably raised.

Sunshine

Sunshine.—If after boiling there is a possibility of bleaching the clothes in the sunshine, the purification is still furthered. “The rays of sunshine act upon the water in the fabric, converting it in the presence of the oxygen of the air into peroxide of hydrogen, which is a very unstable compound, and readily decomposes, giving up ‘nascent oxygen’, which oxidizes organic matter and kills the germs.”

A similar action takes place when clothes are straightened on the grass merely for the purpose of bleaching. “The oxygen converts the colouring matter into a colourless compound.”

The purification or bleaching takes place more rapidly if the moisture in the fabric is somewhat soapy, and if the clothes are spread on the grass, exposing the whole surface to the immediate action of the sun.

Frost

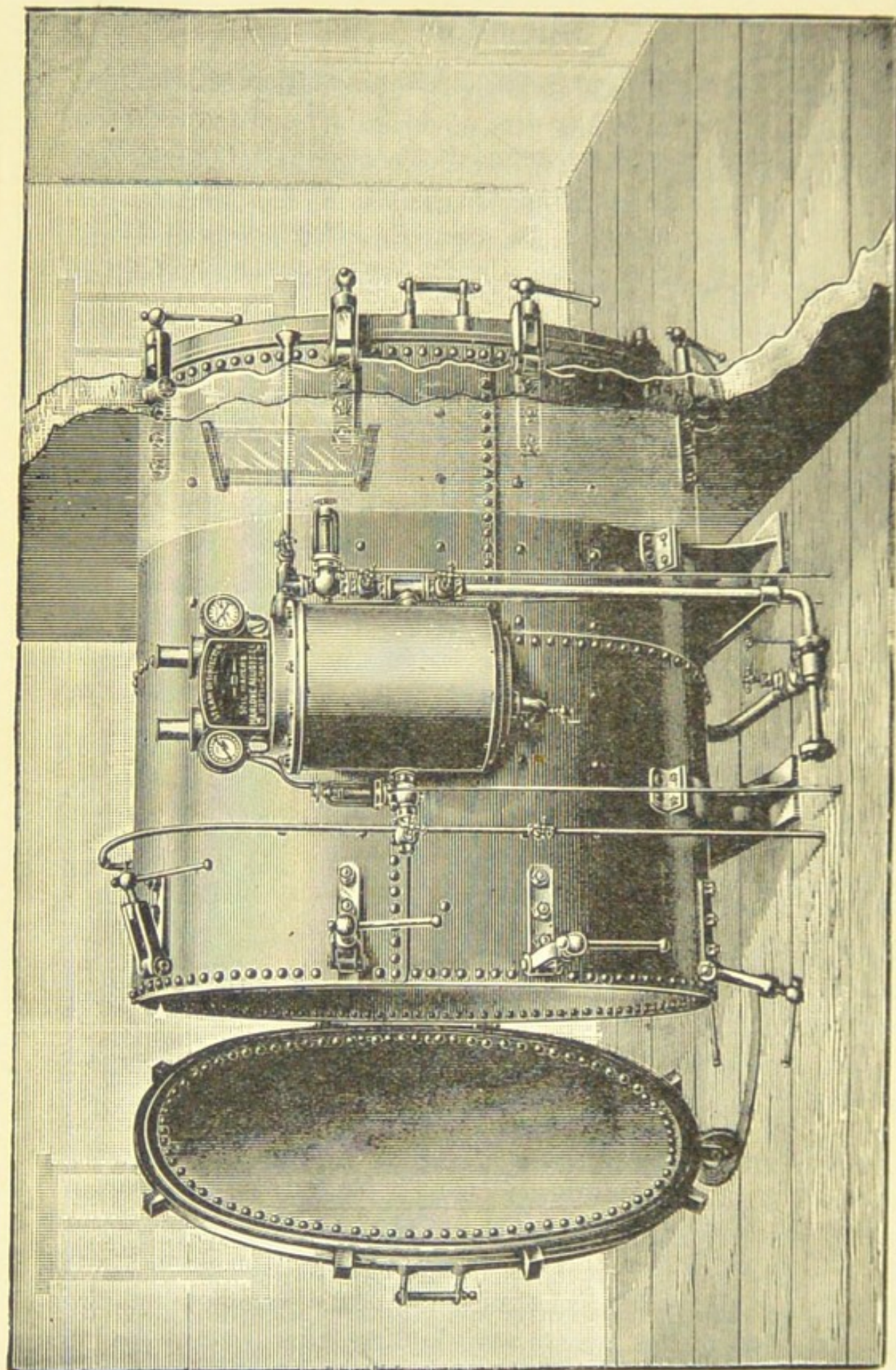
Frost is also said to aid in the bleaching of clothes. In times past, when people used to manufacture their own linen, they preferred the early spring months for the bleaching of it, when the air was clear and frosty, and the sun hot, as they bleached more successfully at that time of the year. It is highly probable that the ozone, which is present in a larger proportion in clear frosty air, is the agent which gives to frost its purifying power.

“Extreme cold does not disinfect, but germs are rendered inactive if exposed to a temperature below freezing-point.”

Saturated Steam under Pressure

The use of *saturated steam under pressure* is another method by which clothes are disinfected, and is the best-known process for purifying infected clothing, especially for large articles, such as mattresses, or clothing that cannot be successfully treated by other methods.

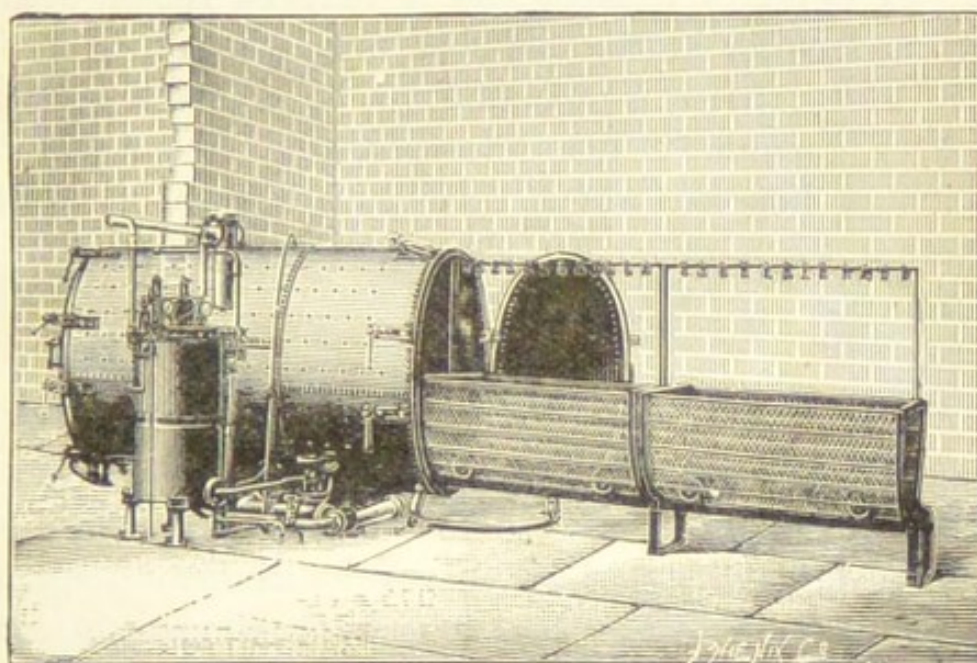
As this cannot be done in an ordinary household, the sani-



Allott-Paton's Patent Improved Lyon High-Pressure Steam Disinfecter.

tary authorities in large towns usually provide a centre fitted up with apparatus suitable for carrying out the work of disinfecting these materials, brought to it for that purpose.

The temperature of saturated steam varies with its pressure. The usual working pressure in the chamber of a high-pressure steam disinfector may be taken at 20 lbs., and a temperature of about 260° F. This, when allowed to penetrate into the interior of any thick material for a length of time, cannot fail to



Alliot-Paton's Steam Disinfector, showing Interior Cage.

destroy even the germs with the greatest powers of resistance, and it has no evil effect on the most delicate fabric or colour.

The apparatus used is either a large oval or cylindrical steam-jacketed machine. (See illustration of Alliot-Paton's patent.) The disinfector is at first heated by means of the steam jacket, to prevent condensation of the high-pressure steam in the interior, and also the wetting of the clothes. A cage or cradle is provided to hold the goods, and when this is filled it is run into the machine. The doors are capable of being closed tightly, to withstand the internal pressure of steam and prevent the ingress of air when the vacuum is applied.

The usual method of operation is to create a vacuum in the chamber. This vacuum is broken by the admission of saturated steam, which is allowed to remain in the chamber

under pressure until it is considered that sterilization has taken place. The action of the steam will be more or less rapid, depending on the character of the articles operated on, and the class of infection to be stamped out. With light articles, and when dealing with germs having but comparatively little resistance to high temperature, only a short time is necessary; while heavy, closely packed goods, and infection due to highly resistant bacteria, may require an exposure of half an hour, or longer; and it may be found desirable to form a vacuum in the chamber more than once.

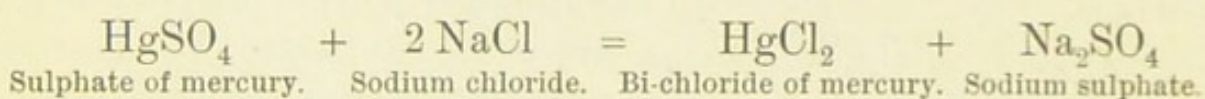
When sterilization is assumed to be complete, steam is shut off, a vacuum is again formed, and followed by the admission of hot air, which removes all trace of moisture. The clothes when taken out are perfectly purified, dry, and ready for use.

Corrosive Sublimate (HgCl_2)

Bichloride of mercury, commonly known as corrosive sublimate, is largely used as a disinfectant, and is generally believed to be the best of all chemical disinfecting agents.

It is prepared in large quantities by heating a mixture of sulphate of mercury and common salt.

The reaction is as follows:—



It is a deadly poison, and its action is also corrosive, and where used for the walls of infected rooms it acts detrimentally on the lead pipes, this being one of the chief drawbacks to its use. When used as a disinfectant, the crystals are dissolved in water; the proportions are one part of the substance to one thousand parts of water, or a little over a drachm to a gallon of water.

The clothes must be steeped in a solution of this strength for an hour or two. Before mixing the solution, it is better to colour the water with washing blue, so that there may be no risk of people using any of it for other purposes.

A solution of the same strength is used for disinfecting walls, ceilings, and furniture; the apparatus employed is a disinfecting sprayer, which disinfects by the action of jets of spray moistening the walls, furniture, and hangings, effectually killing all germs of disease, without injury to material.

Formic Aldehyde

Formic aldehyde is said to be almost equal to corrosive sublimate as a disinfectant, and is safer to use, because of its "volatile and non-corrosive properties". In a pure state it is, when heated, a "colourless gas, possessing a very irritating smell". It may be prepared by passing methyl alcohol and air over red-hot platinum wire.

The clothes are steeped in a solution of one part of formic aldehyde to eight hundred parts of water. (See Appendix for Formalin, page 141.)

Carbolic Acid or Ordinary Phenol (C_6H_5OH)

Carbolic acid is composed of carbon, hydrogen, and oxygen, and is one of the many products of coal-tar. It may also be obtained by dry distillation of resinous substances, but the carbolic acid of commerce is chiefly obtained from coal-tar, which, when distilled fractionally, gives at $170-230^{\circ} C.$, a crude form of the acid, mixed with naphthalene. This is then heated with one of the caustic alkalies, forming a carbolate of sodium or potassium soluble in water, whilst the naphthalene is insoluble. This carbolate is filtered, and decomposed by sulphuric acid, liberating the carbolic acid, which rises to the top as an oily layer, and is usually syphoned off. The product is still further purified, and cooled to $10^{\circ} C.$, when it solidifies into whitish crystals. In this form it is sold for the disinfection of clothing and household goods. There is a cheaper brown liquid form of this acid sold, but, as it is insoluble in water, it is fit only for the disinfecting of drains or similar purposes.

To use carbolic acid for disinfecting, the crystals must be dissolved in water, the proportions being one part to twenty

parts of water. The infected clothes are steeped in this solution for an hour or so; by the end of that time even the most resistant spores ought to be killed.

Carbolic acid is poisonous and corrosive in its action, and, if not carefully used, is apt to destroy fabric.

Notes of Lesson on Different Disinfectants

Aims of Lesson—

1. To teach the object of disinfecting.
2. To teach the different disinfectants generally used, and the methods of using them.
3. To impress upon pupils the great necessity of disinfecting clothes, and to emphasize points of importance while so doing.

Apparatus—

Boiling water, illustration of disinfecting machine, corrosive sublimate, carbolic acid (two kinds), formic aldehyde, black-board, chalk, and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
	<p>Sugg. 1. — There are many diseases that spread rapidly among people.</p> <p>Sugg. 2. — These diseases are due to minute organisms or germs, which are passed from one person to another.</p>	<p>Inf. 1. — Infectious diseases are conveyed by means of germs, and people who are infected should be isolated, and also all clothes worn by them.</p>
<p>Illus. 1. — Show class boiling water, and dip the finger in the water.</p>	<p>Obs. 1. — The water would scald the finger if left in for a time.</p> <p>Sugg. 3. — Boiling water will kill germs, but not the spores; boiling must be repeated.</p>	<p>Inf. 2. — Boiling clothes in water is one of the methods adopted for disinfecting white clothes.</p>
<p>Illus. 2. — Draw the pupils' attention to sunshine.</p>	<p>Obs. 2. — The rays of sunshine are hot in summer.</p> <p>Sugg. 4. — The rays of sunshine (by the action on the oxygen of the air and water) have strong disinfecting properties.</p>	<p>Inf. 3. — The sun is nature's disinfectant, and is a great purifier.</p>

The teacher should here explain the action of sunshine and frost during the purifying of clothes.

Experiments and Illustrations	Observations and Suggestions.	Inferences.
Illus. 3. —Show an illustration of a disinfecting cylinder.	<p>Obs. 3.—It is a large cylindrical apparatus, with doors at both ends and an interior cage, and rod from which to suspend clothes.</p> <p>Sugg. 5.—This apparatus is used for disinfecting large articles, such as mattresses and carpets. They are submitted for a time to saturated steam, which readily kills germs.</p>	Inf. 4. —Saturated steam under pressure is very effectual in killing germs, and is considered one of the best methods for disinfecting large articles.
Illus. 4. —Show corrosive sublimate.	<p>Obs. 4.—It is a white crystalline substance.</p> <p>Sugg. 6.—Corrosive sublimate is composed of mercury and chlorine, and is a deadly poison, yet is one of the best disinfectants known. It must be dissolved in water.</p>	Inf. 5. —Corrosive sublimate is one of the best chemical disinfectants. It is used for washing walls of rooms, and for furniture; also for clothes.

The teacher should here explain proportions and method of using, and also the use of formic aldehyde (show a solution of this).

Illus. 5. —Show different kinds of carbolic acid.	<p>Obs. 5.—One is composed of crystals, the other is a brown liquid.</p> <p>Sugg. 7.—The crystals are pure carbolic acid, the brown liquid is a crude form. The pure substance is used for disinfecting clothing and walls of rooms, the crude is used for drains.</p>	Inf. 6. —There are two forms of carbolic acid, pure and unrefined. The pure form is the only kind that can be used for clothes, as the other would impart a stain.
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The method of using, and proportions, should also be explained.

Black-board Summary

DIFFERENT DISINFECTANTS

Object of disinfecting:—

To destroy germs of disease and so prevent it spreading.

Points to remember:—

1. To keep infected clothes apart from other clothes.
2. To disinfect at once.
3. To use a substance strong enough to kill germs and not to destroy fabric.

Different kinds of disinfectants:—

1. Boiling water.
2. Sunshine.
3. Corrosive sublimate.
4. Formic aldehyde.
5. Carbolic acid.
6. Extreme heat.

Method of using disinfectants:—

1. Boil clothes repeatedly.
2. Boil clothes in soapy water, cool and expose to sunshine for a number of days.
3. Steep clothes in solution of corrosive sublimate for a number of hours, proportion 1 part in 1000 of water.
4. Steep in solution of formic aldehyde, proportion 1 part in 800 of water.
5. Steep clothes in carbolic acid solution, proportion 1 part in 20 of water.
6. The clothes are placed in cylinder, and saturated steam under pressure is applied.

CHAPTER XV.—PARAFFIN

Paraffin-oil is obtained in large quantities as rock-oil, and is found chiefly in Russia and America. The initial expense in the production of this form of rock-oil is the most important item in the cost of production. When the well is sunk the oil is pumped to the surface in a comparatively pure condition, and almost ready for the market.

British Paraffin-oil.—The production of this form of oil is more complicated, as it has to be manufactured from coal or shale. It is prepared in large quantities in some parts of Scotland by the destructive distillation of bituminous coal or

shale. The substance is broken into small pieces, and placed in a retort and heated, when paraffin-oil is distilled over. One ton of coal or shale is said to yield from thirty-two gallons of oil. The oil must be purified by frequent washing with sulphuric acid and caustic soda.

British paraffin is said to be one of the best burning oils, and consequently has withstood the tremendous competition of imported oils.

Paraffin is one of the hydrocarbon series, and is composed of the elements hydrogen and carbon.

The properties of paraffin with regard to laundry work are as follows:—

It has a great grease-solvent property, which renders it valuable for cleansing dirty, greasy clothes; also for cleaning the metal work of machinery, and for the removal of paint stains.

It is volatile in nature, which is another property in favour of its use; but, on the other hand, it has a disagreeable odour, which clings to clothes unless they are hung for a time in the open air. It is also very inflammable, and is dangerous to use near a fire.

The Use of Paraffin in Laundry Work

It is used for the washing of very dirty clothes, in the proportion of one table-spoonful to four or five gallons of boiling water, to which at least one ounce of washing soda and a quarter of a pound of soap have been added.

The clothes, without preliminary treatment, are put into the boiling liquid, and pressed down with a stick until they are wholly under water, and left to boil quickly for about one hour, when they must be removed from the boiler and rinsed thoroughly in at least three hot rinsing waters containing washing soda. This is necessary to remove greasy matter, a certain amount of which adheres to the clothes when they are taken out of the boiler. They should then be blued and hung in the open air to dry, to deprive them of the smell of paraffin.

This method of washing is not to be recommended for clothes that one wishes to keep a good colour. The mere

fact of boiling them in dirty water, which of necessity must be, tends to destroy the whiteness of the material. Yet for very dirty clothes it is highly to be recommended, especially if there is a good supply of hot water.

Paraffin is also used to dissolve grease that has hardened on the metal work of mangles and wringing-machines. The metal work should be oiled with the paraffin, and the machine worked for a minute or so, until the grease becomes liquid, which should then be wiped off with an old duster.

Paraffin is employed for the removal of paint stains. The stain, if on coloured clothes, must be dipped in paraffin and rubbed between the hands, and then washed in soapy water. If the stain is on a white garment, it should be treated as for paraffin washing. If, after boiling, any trace of stain is left, it can easily be removed by washing, and rubbing in soap and water.

Notes of Lesson on Paraffin

Aims of Lesson—

To teach the source, properties, and method of using paraffin in laundry work. To impress the advantages of using paraffin, and also to explain its disadvantages.

Apparatus—

Paraffin, a piece of coal or shale, mangle, evaporating basin, matches, material with paint stains, black-board, easel, duster and chalk, soap and hot water, a few test-tubes, and small basin.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show paraffin, a piece of coal or shale, or both.	<p>Obs. 1.—Paraffin is a liquid, coal and shale are solids.</p> <p>Sugg. 1.—Paraffin is obtained from these rocks by distillation.</p> <p>Sugg. 2.—Paraffin is also obtained from wells sunk in the earth.</p> <p>Sugg. 3.—It is composed of hydrogen and carbon.</p>	Inf. 1. —Paraffin is a mineral oil obtained from coal and shale, and also from sunk wells.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. — Mix a few drops of olive-oil and paraffin, and shake.	Obs. 2. —The oils mix.	
Exp. 2. — Add a little water to the mixture, and shake.	Obs. 3. —A white-looking emulsion is formed.	Inf. 2. — Paraffin renders oil soluble in water.
Exp. 3. —Put a few drops of paraffin into the work of a mangle.	Obs. 4. — The grease dissolves.	Inf. 3. — Paraffin is a grease solvent, and is therefore a cleansing agent.
Exp. 4. —Allow pupils to smell paraffin.	Obs. 5. —It has a disagreeable odour.	Inf. 4. —Paraffin is objectionable because of its smell.
Exp. 5. —Put a few drops of paraffin in an evaporating basin, and apply a light.	Obs. 6. —Paraffin burns.	Inf. 5. —Paraffin is inflammable, and must be used with great caution.
Exp. 6. — Dip a paint stain in paraffin, and rub well, then wash with soap and water.	Obs. 7. —The stain is removed.	Inf. 6. — Paraffin takes out paint stains.

Black-board Summary

PARAFFIN

Source:—

Coal, shale, and deep wells.

Manufacture:—

1. By heating coal or shale in a retort.
2. By pumping from wells.

Properties:—

1. Great grease solvent.
2. Disagreeable odour.
3. Volatility.
4. Inflammability.

Use in laundry work:—

1. To cleanse greasy and dirty clothes.
2. To dissolve grease on metal-work of mangles.
3. To remove paint stains.

Advantages:—

It saves labour and time in washing clothes.

Disadvantages:—

The clothes are apt to become a bad colour, and retain a disagreeable odour.

The quantity of hot rinsing water needed is great.

CHAPTER XVI.—TURPENTINE, &c.

TURPENTINE ($C_{10}H_{16}$)

Turpentine is also one of the hydrocarbons, and is composed of carbon and hydrogen. The turpentine of commerce is obtained from different species of pine trees, and is produced by distillation of the gummy substance which oozes from the bark of the tree, leaving a residue of resin in the retort.

Turpentine is a clear liquid with a characteristic smell; it is volatile in nature, and has the power of dissolving varnish and grease.

It is used in laundry work in conjunction with ammonia to remove paint stains from coloured clothes. The two liquids are mixed, and the stain dipped in and rubbed until it disappears. It is also used in cold-water starch to make the iron pass along the fabric smoothly; proportions, four drops to one table-spoonful of starch.

GUM ARABIC ($C_{12}H_{20}O_{10}$)

Gum arabic is the natural, but dried, exudation from several species of acacias grown in Arabia and Egypt. The chief constituents are the potassium, magnesium, and calcium salts of arabic acid (an acid containing only the elements carbon, hydrogen, and oxygen).

Gum arabic may be bought in two forms—as a brownish, semi-clear solid, and as flour of gum.

It is used in the laundry for stiffening purposes, but must be dissolved in water. It is prepared by washing a quarter of a pound of the cheaper form of gum arabic with cold water, then pouring a quart of boiling water over it, stirring until it is dissolved; it is then strained through muslin and bottled. This liquid is used for stiffening fine articles, such as lace and silk. The proportions vary from a tea-spoonful to a table-spoonful to half a pint of water. Lace invariably requires the larger proportion, and if required rather stiff more is used.

TUNGSTATE OF SODIUM

Tungstate of sodium is composed of the elements tungsten, oxygen, and sodium. It is soluble in water, and is used in laundry work to render garments unflammable, and is usually added to the starch; proportions, one ounce to a pint of hot-water starch.

BENZOLINE

Benzoline is a mixture of hydrocarbons (*e.g.* C_6H_{12}), and is therefore composed of hydrogen and carbon.

Benzoline is procured as a distillate from American petroleum, being the part boiling between $70^{\circ} C.$ and $100^{\circ} C.$

Properties of Benzoline

It is a colourless liquid and is very volatile, for this reason the vessels in which it is kept must be tightly corked to prevent evaporation.

It is inflammable, and should never be used in a room with a fire or light. It dissolves gutta-percha, wax, and fatty substances, and consequently is largely used for removing certain stains and dirt from clothing.

Its Use in Laundry Work

It is chiefly employed in the laundry for the cleansing of clothes that cannot be successfully treated with soap and water.

For example, glacé silk garments, which lose their gloss and scroop entirely when washed, if cleaned with benzoline retain the natural gloss and stiffness. Silk laces, kid gloves, and furs, none of which can be successfully washed, are all cleaned with benzoline.

The articles are usually washed in a bath of benzoline, and if very dirty a little benzene soap is added to the first bath. The articles are squeezed and pressed, and the dirtiest parts brushed with a soft brush, which is better than rubbing. They are then rinsed in clean benzoline, wrung, and rolled

lightly in a clean cloth to remove the benzoline, then hung in a warm place to dry until the spirit is wholly evaporated and the smell removed. The silk and lace are then pressed with a hot iron. Kid gloves, if white, are improved if rubbed with French chalk.

Notes of Lesson on Turpentine, Gum Arabic, Tungstate of Sodium, and Benzoline

Aims of Lesson—

To teach composition, source, properties, and use of the above substances.

Apparatus—

Turpentine, gum arabic (two specimens), tungstate of sodium, benzoline, water, resin, piece of pine-tree, blotting-paper, jar of chlorine gas, blue litmus, oil, test-tubes, evaporating-basin, matches, piece of calico, hot iron, shirt-board (covered), iron-holder, iron-stand, piece of muslin, bunsen burner, flat dish, chalk, duster, black-board and easel.

TURPENTINE

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. — Show class resin, turpentine, and piece of pine-tree, if possible with resinous substance attached, and allow pupils to smell turpentine.	Obs. 1. —Resin is a yellowish solid; turpentine is a clear liquid with a strong smell; the pine wood has a gummy sticky substance on the bark. Sugg. 1. — The gum-looking substance when heated evolves a clear liquid with a strong smell, and leaves a hard yellow residue.	Inf. 1. — Turpentine is a clear volatile liquid, obtained from gummy matter oozed from pine-trees, and resin is left as a residue.
Exp. 1. —Place a piece of paper, moistened with warm turpentine, in a jar of chlorine gas, and afterwards a few drops of water and litmus (blue).	Obs. 2. —The turpentine burns, and leaves a black deposit of carbon on sides of tube; blue litmus is turned red. Sugg. 2. — The hydrogen and chlorine combine to form hydrochloric acid.	Inf. 2. — Carbon and hydrogen are constituents of turpentine.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 2. — Add a few drops of oil to a little water in a test-tube, and shake; add a little turpentine, and again shake.	Obs. 3. —Oil and water do not mix; turpentine, oil, and water mix. Sugg. 3. — Turpentine is added to cold-water starch to make the iron work smoothly.	Inf. 3. —Turpentine dissolves grease. Inf. 4. —Turpentine has the property of an oil, and makes the iron glide smoothly.

GUM ARABIC

Illus. 1. — Show class gum arabic.	Obs. 1. —It is a semi-clear solid. Sugg. 1. —Gum arabic is obtained from certain trees in Arabia and Egypt.	Inf. 1. —Gum arabic is of vegetable origin, and is obtained from certain acacia-trees.
Illus. 2. —Show flour of gum.	Obs. 2. —It is a brownish-yellow powder.	Inf. 2. —Gum arabic is sometimes powdered and used as starch.
Exp. 1. — Dissolve a small quantity of gum in boiling water, dip a piece of calico in solution, wring and iron.	Obs. 3. —The calico becomes stiff.	Inf. 3. —Gum is used to stiffen certain fabrics.

TUNGSTATE OF SODIUM

Illus. 1. — Show tungstate of sodium.	Obs. 1. —It is a white solid.	Inf. 1. — Tungstate of sodium is a white solid substance, soluble in water.
Exp. 1. —Add a small quantity to a little water.	Obs. 2. —It dissolves in the water.	
Exp. 2. — Dip a small piece of muslin in solution, dry, and hold in gas flame.	Obs. 3. —Muslin smoulders, but does not burn with a flame.	Inf. 2. — Tungstate of sodium renders garments non-inflammable, and should be used in starch for children's muslin clothing.

BENZOLINE

Illus. 1. — Show class benzoline, and allow students to smell, and expose a few drops of benzoline to the air on a flat dish.	Obs. 1. —It is a clear liquid with a characteristic smell. The benzoline evaporates.	Inf. 1. —Benzoline is a clear volatile liquid, and may be recognized by its odour.
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Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Add a small quantity of benzoline to a few drops of oil.	Obs. 2. —Oil and benzoline mix.	Inf. 2. —Benzoline dissolves grease, and is useful for cleansing clothes that cannot be successfully washed.

Black-board Summary

TURPENTINE, GUM ARABIC, SODIUM TUNGSTATE, AND BENZOLINE

TURPENTINE

Source:—

Pine-trees.

Manufacture:—

By distilling gummy substance in retort.

Properties:—

Clear liquid.

Smell.

Grease solvent.

Use in laundry work:—

To remove paint stains.

To make the irons glide smoothly over the work.

GUM ARABIC

Source:—

Acacia-trees.

Properties:—

Semi-clear solid.

Stiffening property.

Use in laundry work:—

To stiffen laces and silks.

TUNGSTATE OF SODIUM

Use in laundry work:—

To render muslins non-inflammable.

BENZOLINE

Source:—

Petroleum.

Properties:—

Clear liquid.

Odour.

Volatility.

Grease solvent.

Inflammability.

Use in laundry work:—

To cleanse clothes that cannot be successfully washed.

CHAPTER XVII.—WOOL

Wool is the natural covering peculiar to certain species of animals, but more especially that of the sheep, which is capable of producing a fleece of wool every twelve months; this is removed by a process known as shearing. The fleeces are then rolled together, weighed, packed, and sold to the manufacturers.

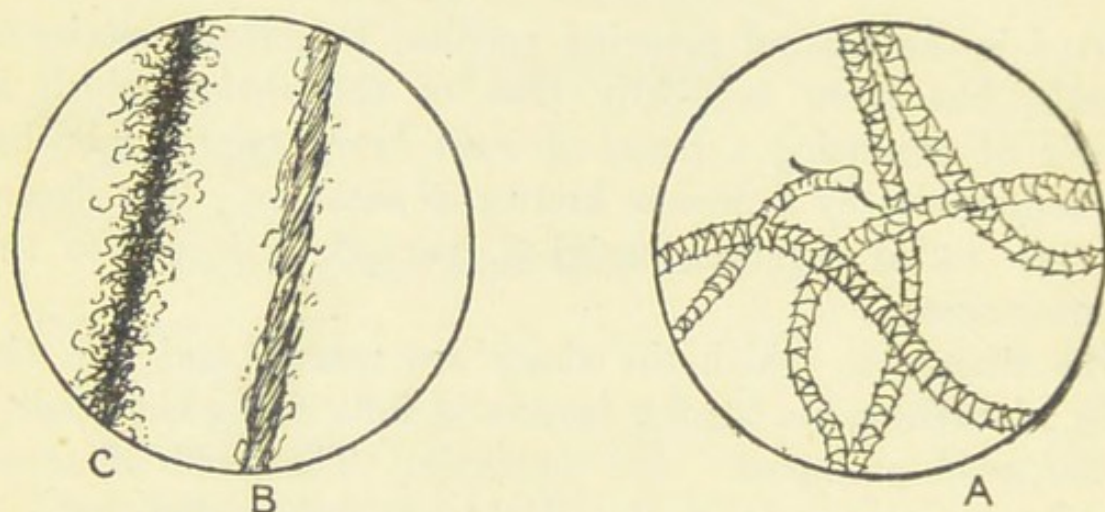
The climate in which the sheep are reared, and also the mode of feeding, are strong factors in influencing the quality of the wool produced. For example:—The wool of sheep reared on some parts of the Highlands, where the grass is coarse and rank, is long in staple and coarse in fibre, and fit only for the making of blankets, carpets, or rugs; but the wool of sheep fed on the pasture land of different counties of the south of England and Wales, also the Cape of Good Hope, to a certain extent lacks shrinking property, and is more suitable for the manufacture of flannels and shawls, where felting has to be avoided.

Australian, German, and New Zealand wools are fine in fibre, soft, and much given to shrinking, and are more suitable for clothing that has to be thoroughly felted before being made up into garments.

The Structure of the Wool Fibre

The wool fibre, under the microscope, is seen to consist of cells, the outer ones appearing irregular in shape, and to a certain extent overlapping each other. This is commonly

known as serrations in the fibre. This superficial appearance plays an important part in causing the shrinking of flannel. As long as wool remains on the sheep, it has no inclination to shrink, or felt, even if it is wet or rubbed. Moisture and rubbing are also necessary factors in the production of a felted material; the reason given is, the serrations on the fibre all point one way, from the root downwards, and in consequence cannot interlock, and felting is impossible. Wool that has been manufactured has the fibres lying in every direction, and shows many surface fibres (see illustration C);



A, Wool Fibres; B, Worsted Thread; C, Woollen Threads. (Magnified.)

and the serrations opposing each other interlock, and under the influence of moisture, soap, heat, and rubbing, become bound together, and the wool shrinks sometimes to one-third of its size, making the fabric thick and hard. This action is hastened by the addition of soda to the water.

When wool is arranged for the making of worsted material, the fibres are combed so as to lie as far as possible in one direction, leaving few surface fibres (see illustration B), and by this means reducing the shrinking property to a large extent.

Composition

Experiment 39.—The cleaned wool fibre is said to consist of carbon, hydrogen, nitrogen, oxygen, and sulphur, and if dried wool be heated in a dry test-tube, it decomposes, water is deposited on the sides of the test-tube, and ammonia gas, which

turns red litmus blue, is evolved. On further heating, a gas which blackens paper moistened with lead acetate (sulphuretted hydrogen) is evolved. Thus, by the application of heat the presence of all constituents may be discovered. Another test for the presence of sulphur and nitrogen is as follows:—

Experiment 40.—Place a piece of white wool in a solution of caustic soda; the wool dissolves, and a gas turning red litmus blue is evolved (ammonia). To the solution add dilute hydrochloric acid and warm; hydrogen sulphide is evolved, which gives dark coloration to paper moistened with lead acetate.

Properties of Wool

Wool is very absorbent, and is capable of taking up a large percentage of water. This property renders it invaluable as clothing material, as it is less likely to give chill to the wearer if it becomes unavoidably damp, than cotton or linen would under similar circumstances. Wool, when wet, is plastic, retaining almost any shape into which it may be drawn, hence special care must be taken to keep woollen garments in good shape during the process of washing and drying.

Wool lacks the property of conducting heat from one body to another, and for this reason it is exceptionally good as an article of clothing.

In cold weather it enables the body to retain its natural heat, by preventing the warmth passing away from it. In hot weather it also prevents the heat of the sun from making the wearer feel uncomfortably hot, it absorbs the moisture given off by the pores of the skin, and invariably prevents chill.

The fineness, softness, lightness, and elasticity of wool also tend to make it superior to any other material for clothing purposes. Being soft and light, it is easy to wear, and the elastic property enables it to cling to the body, keeping it warm.

The elasticity of wool is said to be due to the “density of the inner cells of the fibre”.

Action of Alkalies on Wool

The chief constituent of the woollen fibre is of a gelatinous nature, and the caustic alkalies, *e.g.* caustic soda or potash, when used even as weak solutions, if hot, will dissolve the fibres, giving sulphides.

“Action of water on wool yields sulphuretted hydrogen (H_2S).
,, alkalies ,, sodium sulphide (Na_2S), &c.”

The alkaline carbonates and inferior soap have a similar action on wools, but their strength having been previously modified they are less destructive than the caustic alkalies; yet they must be carefully avoided for the cleansing of woollen materials, as their action on the surface cells is derogative, softening the gelatinous substance, which during the drying process shrinks and becomes hard. All alkaline substances except potash, which is the alkali naturally produced in the fibre, tend to make white wool yellow in colour; it is therefore better to use a potash soap for the washing of woollen clothing.

Action of Acids on Wool

Dilute sulphuric or hydrochloric acids have little action on woollen fabric, but concentrated forms of these acids act on it, causing it to swell, and tender, although their action is not so destructive on wool as on cotton.

Action of Bleaching-Liquor (“Chloride of Lime”)

Bleaching-liquor has also a destructive action on all wools. In the first place, it gives to white wool a yellow colour, and eventually destroys the fabric, so its use must be avoided.

Bleaching of Wool

The agent usually employed for bleaching woollen material is sulphur dioxide. This is only necessary when wool is to remain white. The wool or woollen fabric must be quite clean by washing, and while wet hung up in an air-tight

chamber, the sulphur ignited, and the material allowed to hang in the fumes overnight.

Other alternatives are to steep the wool in a solution of sulphurous acid or peroxide of hydrogen; but both of these methods are more expensive than that done in the fume-chamber, and are not so often resorted to.

Washing of Woollen Material

When washing flannels, or other woollen materials, the temperature of the water used should be from 35° C. to 45° C., or lukewarm, as hot water would act injuriously on the fibres. Soap solution is necessary for the successful cleansing of flannel. This should be added to the water until a slight lather is formed; a strong lather must be avoided, as it tends to make the flannel shrink.

For undyed flannels the water should be made slightly alkaline with ammonia before the soap is added; the quantity used depends upon the strength of the ammonia. If it is the strongest form, "·880 specific gravity", a small table-spoonful to a gallon of water will be ample; but if it is one of the made-up ammonium compounds, such as cloudy ammonia, which is less strong, more is necessary. Flannels, if undyed, may be steeped from twenty minutes to half an hour in the prepared washing water; this dissolves the grease and dirt, and less friction is required for cleansing.

The washing should be done as far as possible by squeezing or kneading against the bottom of the tub, as rubbing helps to entangle the surface fibres, and is one of the causes of shrinking, although rubbing is not so detrimental to flannel as too strong an alkaline solution.

All woollens should be thoroughly rinsed after washing to remove all traces of soap, then wrung tightly and shaken to loosen the surface fibres, and dried in the wind. This treatment helps to preserve their softness and elasticity.

Notes of Lesson on Wool

Aims of Lesson—

1. To teach the source, structure, composition, manufacture, and properties of wool.
2. The destructive action of certain chemicals on wool.
3. The bleaching and careful washing of wool so as to avoid shrinking.

Apparatus—

Piece of wool fleece, illustration of magnified wool fibre and threads, test-tubes, bunsen burner, lime-water, pieces of white and coloured flannel, caustic soda, lead acetate, water, piece of linen or cotton, paper, washing soda, vinegar, hydrochloric acid, bleaching-powder solution, melted soap and warm water, basins, a few beakers, black-board, easel, chalk and duster.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show a piece of wool fleece.	Obs. 1. —It consists of long wavy hairs or fibres. Sugg. 1. —Wool is the natural covering of the sheep and goat.	Inf. 1. —Wool is of animal origin, and is obtained from sheep and goats.
Illus. 2. —Show magnified wool fibre.	Obs. 2. —It has a wavy, irregular appearance, with surface cells overlapping each other. Sugg. 2. —When the surface fibres meet in opposite directions they interlock, and draw the wool together. Sugg. 3. —Wool as it grows on the animal cannot shrink, as the fibres are all lying in one direction and cannot interlock.	Inf. 2. —The surface cells of the fibre are the chief factors in the shrinking of wool.
Exp. 1. —Heat dried wool in a dry test-tube, and hold a piece of red litmus paper in mouth of test-tube, and hold piece of paper moistened with lead acetate over mouth of tube.	Obs. 3. —Red litmus-paper becomes blue. Obs. 4. —Moisture is deposited on tube. Obs. 5. —The wool chars. Obs. 6. —Paper is blackened (presence of H_2S , hydrogen sulphide).	Inf. 3. —There is an alkaline gas given off, probably ammonia. Inf. 4. —Carbon and water are also present. Nitrogen, hydrogen, carbon, oxygen, and sulphur are constituents.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 2. —Put a piece of white wool in a solution of caustic soda, and heat. Hold over test-tube a piece of litmus paper. Then acidify with dilute HCl and warm. Hold paper moistened with lead acetate over mouth of tube.	Obs. 7. — The litmus-paper becomes blue. Obs. 8. —The paper becomes dark in colour. Sugg. 4. —Lead acetate gives dark coloration to paper in presence of hydrogen sulphide gas.	Inf. 5. —Presence of ammonia. Hydrogen sulphide is evolved from wool (presence of sulphur in wool).
Exp. 3. —Place a piece of wool and cotton in a small quantity of water, squeeze out, and place on the back of the hand.	Obs. 9. —The wool has absorbed the water and is less saturated than the cotton, and does not feel so cold to the touch.	Inf. 6. — Wool absorbs moisture and does not give chill to the wearer. This renders it valuable as an article of clothing.
Exp. 4. —Pull a woollen garment between the hands.	Obs. 10. — The wool stretches. Sugg. 5. —Wool is a non-conductor of heat.	Inf. 7. —Wool is elastic, and as it does not take heat away from the body it is more comfortable to wear.
Illus. 3. —Show a piece of wool, and also a piece of cotton or linen.	Obs. 11. —Wool is soft, fine, and light. Linen is heavy and hard.	Inf. 8. —Wool is valuable as an article of clothing, as it is light, soft, and warm.
Exp. 5. —Put a piece of wool into a solution of caustic soda, and heat.	Obs. 12. —The wool is dissolved.	Inf. 9. —Caustic soda entirely destroys wool.
Exp. 6. —Steep a piece of flannel in washing-soda solution.	Obs. 13. — The colour runs and flannel becomes hard and felted, and if boiled for a time is dissolved.	Inf. 10. —Washing soda has an action similar to caustic soda, but feebler.
Exp. 7. —Steep a piece of woollen material in vinegar.	Obs. 14. —The fabric is not impaired.	Inf. 11. —Vinegar has no action on wool.
Exp. 8. —Immerse piece of wool in strong hydrochloric acid and warm.	Obs. 15. — The wool swells, and is "tendered".	Inf. 12. — Strong acids destroy wool.
Exp. 9. —Steep a piece of flannel in bleaching-powder solution for a time.	Obs. 16. —The colour and fabric are destroyed.	Inf. 13. —Bleaching-powder solution removes colour and rots fabric.

The teacher should here explain the process of bleaching wool.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 10. —Wash a flannel garment in lukewarm soap lather by squeezing if possible, then rinse, wring, shake, and dry quickly.	Obs. 17. —The flannel is quite soft, and has not shrunk.	Inf. 14. — Flannels retain their softness and elasticity if carefully washed in lukewarm soap lather and dried quickly.

Black-board Summary

WOOL

Sources:—

Wool is the natural covering of the sheep and goat.

Composition:—

Carbon, hydrogen, nitrogen, oxygen, and sulphur.

Properties:—

1. It is light, soft, fine, and a non-conductor of heat.
2. It is absorbent and elastic.

Action of alkalies:—

If steeped in caustic-soda solution, wool is dissolved.

Action of washing soda:—

Is similar in action, but less corrosive.

Action of chlorine:—

It destroys colour and fabric.

Action of acids:—

Weak acids have no action.

Strong acids act on fabric, but not so readily as with cotton.

Wool is bleached in sulphurous fumes and solution of peroxide of hydrogen.
Wool should be washed in lukewarm soap lather by squeezing if possible.

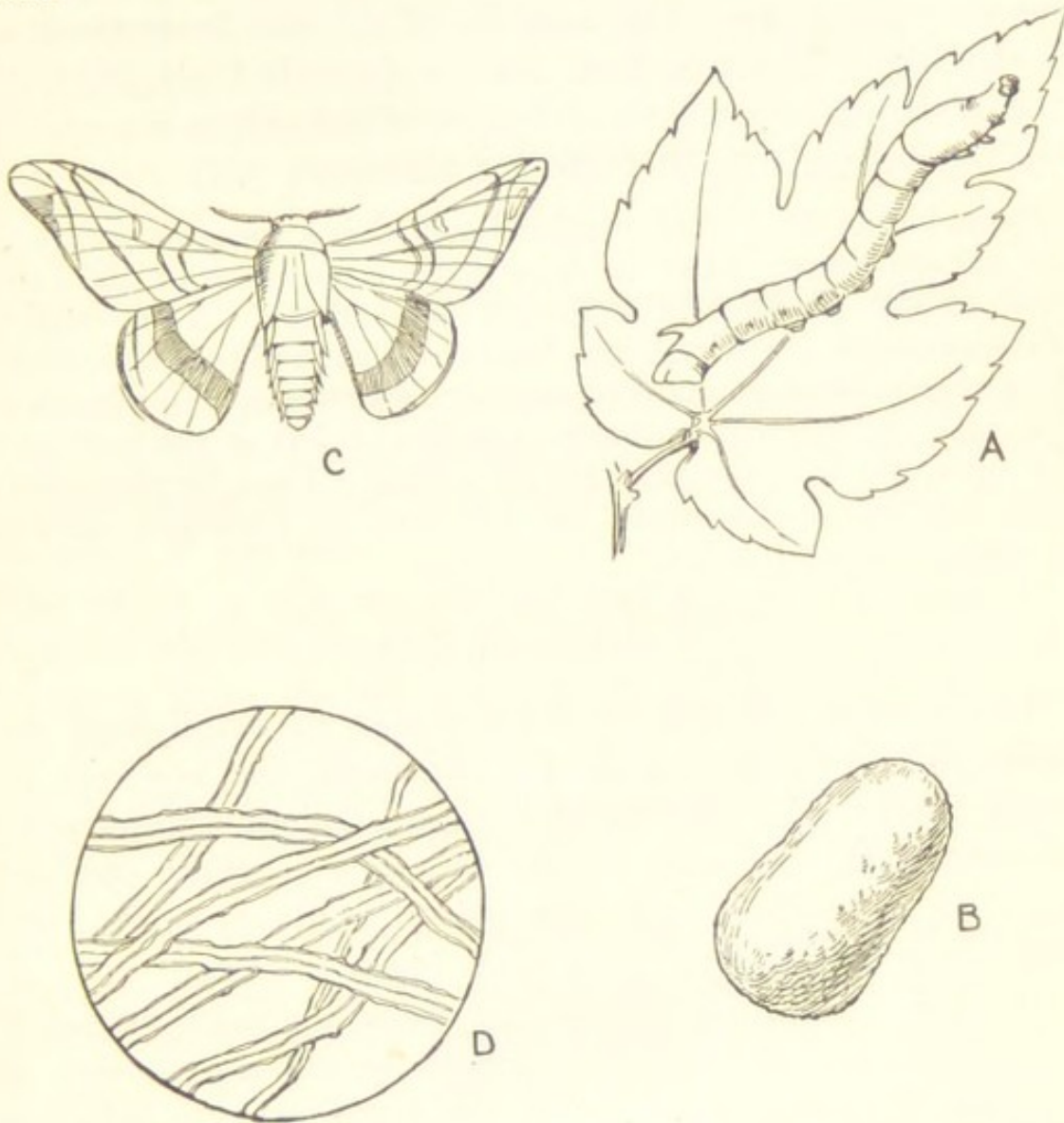
CHAPTER XVIII.—SILK

Its Origin

Silk is a fine glossy thread consisting of pale-yellow or white fibres, produced by the silk-worm, which it spins around its body when entering into the chrysalis state.

The principal kinds of silk are the *cultivated* and the *raw*. The former is produced by a species of silk-worm, the moth

of which is known as *Bombyx mori*, and is largely cultivated in China, India, Japan, and the south of France. As the food of these silk-worms chiefly consists of the leaves of the mulberry tree, the material is sometimes known as mulberry silk.



A, Silk-Worm on Mulberry Leaf. B, Cocoon. C, Moth. D, Silk Fibres, magnified

The raw silk is produced by several species of silk-worms, the most important being Tussor, from the Tussah silk-worm, which is a native of India, and several others, which are natives to China and Japan. The wild silk produced by these worms is much darker in colour and somewhat coarser in fibre than the cultivated or mulberry silk, and is to be highly recommended for its durability.

Composition

The silk fibre has been thoroughly examined by different experts, and has been found to consist of "an outer coat of *silk gum* or *sericin* and an inner layer of *fibroin*", which is the pure silk fibre. The formula of this has been given as $C_{15}H_{23}N_5O_6$. The silk gum has the formula $C_{15}H_{25}N_5O_8$.

The simple experiment of heating dried silk in a perfectly dry test-tube gives the following result:—

Experiment 41.—Heat the tube containing the silk gently in the bunsen flame; water is deposited on the sides of the tube, showing the presence of hydrogen and oxygen. A gas with a pungent odour is evolved, and turns red litmus blue; this shows the presence of ammonia (nitrogen and hydrogen). Finally, there is a smell of charring, and a black residue is left at the bottom of the tube, showing the presence of carbon. Thus, by elementary tests one can demonstrate the presence of hydrogen, oxygen, nitrogen, and carbon.

Culture of Silk

The eggs of the silk-worm are placed in well-lighted and thoroughly-ventilated incubation chambers, and are kept for about twelve days; during that time a suitable temperature is maintained. As soon as the caterpillars appear they are removed to another room, and fed on mulberry leaves for a little over thirty days, until they begin to spin.

During the feeding process the worm increases in size so rapidly that it is obliged to moult, or change its skin, at intervals of about a week; when the worm ceases to take food it is placed on birch twigs, and remains until the spinning period is over.

The silk is secreted by two glands, which terminate in one duct, situated in the head; the two fibres are combined into one, and thus forming a double fibre, which may be seen distinctly if highly magnified. From this duct the silk-worm throws the thread around, forming at first a light net-work too large for its body; when this stage of the work is completed the animal quietens down, and gradually lines its

cocoon with silken threads. As soon as the spinning process is finished, the cocoons are placed in steam for about ten minutes. This is done to kill the moths and to prevent them breaking through the cocoons, which are then sorted according to the quality of the silk, the stronger threads being reserved for the warp of the material, because of the greater strain that is brought to bear on these threads during the process of weaving, the more slender and delicate fibres being reserved for the weft. (For Properties of Silk, see Appendix, page 142.)

Manufacture

The first step in the method of manufacture of silk is the steeping of the cocoons to soften the gummy substance from the fibres, and enable the reeler to separate them from the cocoon. Great care must be taken by the worker who supervises the reeling process, as carelessness detracts greatly from the quality of the silk.

The hanks of silk are washed and lusted by means of stretching and twisting. If the fabric is to be prepared in the undyed state, the silk is now ready for weaving. If it is to be made into colours, the silk yarn is boiled in soap and water to remove all the natural gum; this process usually deprives it of one-fourth of its weight, but this is made up by the dyes it absorbs.

Silk overweighted with dye has its disadvantages, as it is said to "cut more easily, and in consequence wears out quickly".

Silk waste is collected, carded, and spun, and is known as spun silk. This is often used for lining silk. The lustre of silken fabrics, such as satin, is greatly due to the warp threads showing on the surface of the material, and also to the fact that it is passed over heated steam during the finishing process.

Bleaching

The bleaching of silk is similar to the methods for bleaching wool by stoving the yarn in the sulphurous fumes for a number of hours. Two pounds of sulphur is generally allowed to fifty pounds by weight of silk.

Another method is to steep the silk for a time in a solution of peroxide of hydrogen.

This is said to be the best bleaching agent for all animal fibres, as it has no injurious action on the apparatus, and does not affect the operators, and the fabric retains its whiteness for a longer period.

Action of Various Chemicals

Caustic soda and caustic potash in solution, especially if hot, rapidly dissolve silk; cold and weak solutions are less active, but even these impair the whiteness and lustre of the silk, and eventually destroy the fibres.

Experiment 42.—Dissolve a piece of caustic soda, and place a small piece of coloured silk in the liquid, and heat for a few seconds. The liquid becomes coloured, and the silk entirely disappears. The animal fibres are dissolved by the caustic alkali. A piece if left steeping in a cold solution for an hour or two gives the same result.

The carbonates of sodium and potassium, although less energetic, have also a destructive action on silk, and should never be used as a cleansing agent for that fabric.

Experiment 43.—Place a piece of silk in solution of sodium carbonate and boil for a time; the fibres become "tendered" or rotten, also the colour is partially taken out, proving conclusively that soda has a detrimental effect on silk, although the experiment is rather extreme on purpose to hasten the chemical action. Soap, of all the alkaline agents, has the least injurious effect, and is the only one that can be safely used for the thorough purifying of the silk fibre.

Chlorine has also a destructive action on silk, in the first place making the silk yellow, and eventually destroying the fibre. Hence it must never be used, even for the removal of stains from silk.

Experiment 44.—Place a piece of silk in solution of bleaching-liquor, or in a jar containing chlorine gas. The silk, if coloured, loses its colour and becomes yellow; if white it also becomes yellow, and in a few minutes the fibre is destroyed, the action of chlorine being more strong on animal than vegetable fibres.

Action of Acids.—Concentrated mineral acids dissolve silk completely, but if weak solutions are used they have no appreciable action. A dilute solution of acetic acid, or vinegar, is sometimes used to restore lustre to silk; it has no detrimental effect on the fabric.

Washing of Silk

The preparation for, and the initial steps in, the washing of silk are similar to those for washing wool, and need not again be described, but it must be remembered that silk should never be rubbed, or wrung by twisting, which if done might displace or break the fibres. After thorough rinsing, the silk is usually stiffened in a solution of gum water (proportion—one dessert-spoonful to half a pint of cold water), squeezed out and rolled in a cloth for a short time, and ironed on the right side unless there is a raised pattern, when it must be ironed on the wrong side to raise the work on the right side. Tussor silk should not be stiffened. Gum-water deprives it of its natural softness, giving it the appearance of paper.

Notes of Lesson on Silk

Aims of Lesson—

1. To teach the source, culture, and manufacture of silk.
2. To show and compare different kinds of silk.
3. To explain composition and properties of the fabric.
4. The bleaching of silk.
5. The destructive action of alkalies, washing soda, and chlorine.
6. To teach how to wash silk.

Apparatus—

Silk fibres, cocoon, illustration of silk moth and caterpillar (mulberry leaves if possible), test-tubes, pieces of different kinds of silk, piece of sulphur, and small bottle of peroxide of hydrogen, apparatus and materials for generating sulphur dioxide, caustic soda, washing soda, litmus paper, chlorine water, a few beakers, soap, water, basins, covered shirt-board, iron-holder, towels, duster, chalk, black-board and easel.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show class cocoon, silk fibres, illustration of silk-worm moth, and mulberry leaves if possible.	<p>Obs. 1.—Cocoon is egg-shaped, yellowish in colour, and has an irregular surface.</p> <p>Obs. 2.—The silk fibres are very fine and glossy; some white, others yellow and brownish-gray.</p> <p>Sugg. 1.—The caterpillar feeds on mulberry leaves, and spins its silken thread around its body to form a cocoon.</p>	<p>Inf. 1.—Silk is a beautiful lustrous material; the natural colours are white, yellow, and brownish-gray.</p> <p>Inf. 2.—Silk is of animal origin, and is the product of the silk-worm.</p>
The teacher should here explain the culture and manufacture of silk.		
Exp. 1. —Put a piece of well-dried silk in a perfectly dry test-tube and heat.	Obs. 3. —Water collects on sides of test-tubes.	Inf. 3. —The deposition of water on sides of test-tube indicates the presence of hydrogen and oxygen in silk.
Exp. 2. —Hold red litmus paper in mouth of test-tube.	Obs. 4. —The paper becomes blue.	Inf. 4. —Alkalies change red litmus blue, an alkaline gas has been evolved (ammonia, indicating the presence of nitrogen and hydrogen).
Illus. 2. —Show class test-tube with residue.	<p>Obs. 5.—A black charred substance adheres to the sides of tube.</p> <p>Sugg. 2.—Many carbonaceous substances when heated become black.</p>	Inf. 5. —Black residue is a deposit of carbon, proving its presence in silk.
Illus. 3. —Show specimens of different kinds of silk.	<p>Obs. 6.—The different pieces vary in colour; all are lustrous, and some pieces have a crisp sound.</p> <p>Sugg. 3.—The colours are imparted to silk by means of dyes.</p>	Inf. 6. —The lustrous appearance and crisp sound are properties of silk.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 4. —Show a piece of sulphur and a small quantity of peroxide of hydrogen.	Obs. 7. —One is a yellow solid, and the other a clear liquid. Sugg. 4. —If silk is required quite white, it must be bleached.	Inf. 7. —Silk is bleached in fumes of burning sulphur, or by steeping in a solution of peroxide of hydrogen.
Exp. 3. —Dissolve a small piece of caustic soda or potash, and steep a piece of silk in the hot solution.	Obs. 8. —In a few minutes silk disappears, becomes dissolved.	Inf. 8. —Caustic alkalies entirely destroy silk.
Exp. 4. —Place a piece of silk in solution of washing soda, and boil for a time.	Obs. 9. —First stage, silk loses its colour. Finally fibres become destroyed, or “tendered”.	Inf. 9. —Washing soda, although less energetic, has also a destructive action on silk, and its use must be avoided.
Exp. 5. —Put a small piece of silk in chlorine water, and leave for a few minutes.	Obs. 10. —The silk becomes yellow, and fabric is destroyed.	Inf. 10. —Chlorine destroys both colour and fibres of silk.
Exp. 6. —Wash specimens of different kinds of silk, one by rubbing, other by squeezing in soap lather.	Obs. 11. —Silk that was rubbed has fibres displaced, those pieces washed by squeezing have not.	Inf. 11. —Silk must be washed by squeezing, as rough treatment destroys fabric.
Exp. 7. —Iron the different pieces while wet.	Obs. 12. —Most of the pieces of white washing silk becomes lightly stiff and glossy. Obs. 13. —Tussor silk becomes too stiff.	Inf. 12. —Most of the various specimens must be ironed while wet.
	Obs. 14. —Glacé silk loses its stiffness and part of its gloss.	Inf. 13. —Tussor silk increases in stiffness if ironed wet.
		Inf. 14. —Glacé silk loses its crispness, or “scroop”, and its gloss when washed, and ought to be dry cleaned.
Exp. 8. —Almost dry a piece of Tussor silk, and iron.	Obs. 15. —Silk is less stiff and more glossy.	Inf. 15. —Tussor silk should be partly dried before it is ironed.

Black-board Summary

SILK

Source:—

Silk is of animal origin—the product of the silk-worm.

Kinds:—

The chief kinds are the cultivated and raw silk.

Composition:—

Silk is a compound of carbon, hydrogen, oxygen, and nitrogen.

Properties:—

Silk is absorbent, lustrous, and crisp, and a bad conductor of heat.

Bleaching of silk:—

Silk may be bleached in sulphurous fumes, or peroxide of hydrogen solution.

Action of alkalies:—

Caustic soda or potash dissolves silk entirely.

Action of washing soda:—

Washing soda turns white silk yellow, destroys colour in coloured silk, and rots the fabric.

Washing of silk:—

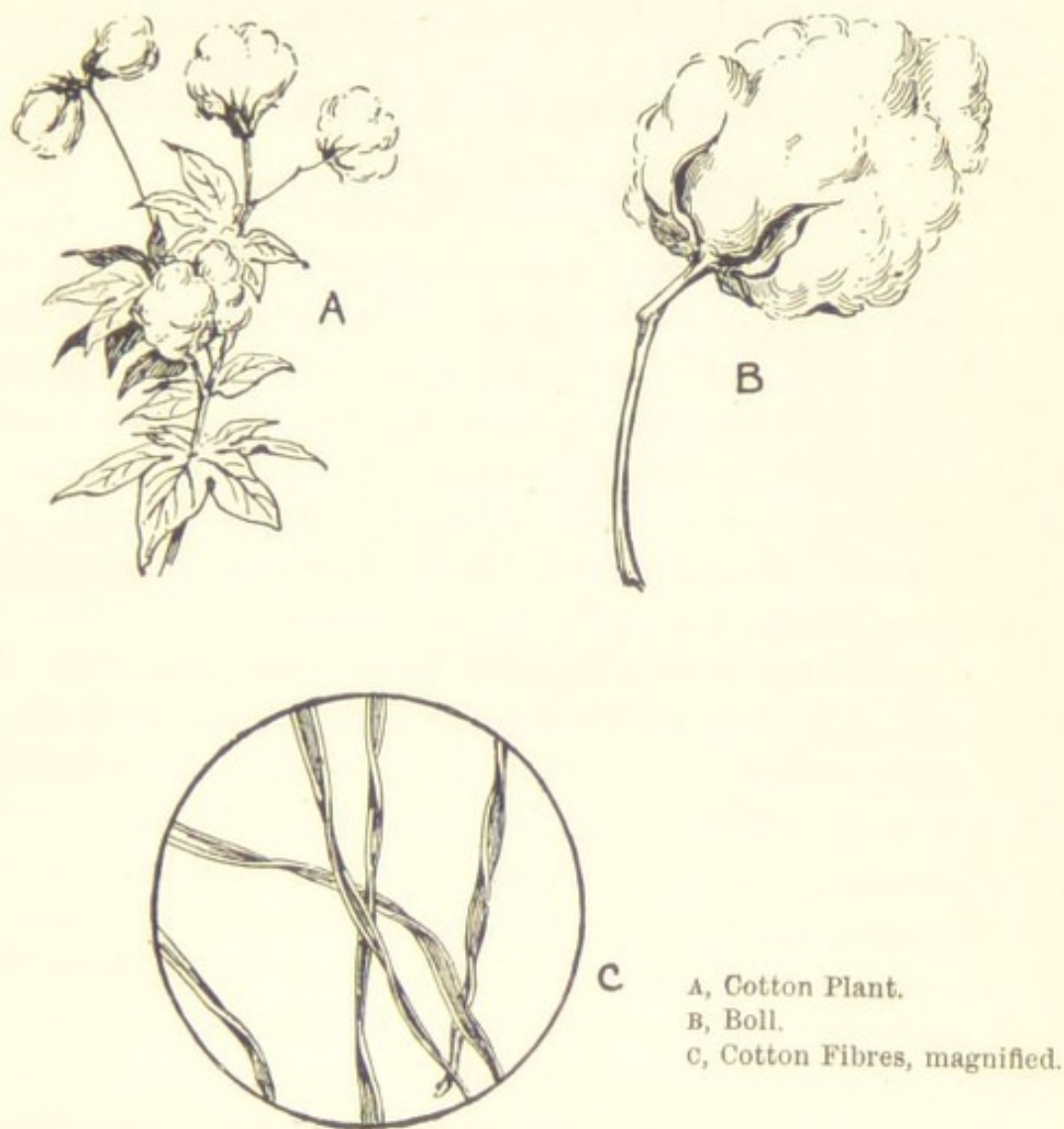
Rubbing displaces fibres, therefore silk must be washed by squeezing, and ironed on right side to give a gloss.

CHAPTER XIX.—COTTON

Cotton, unlike wool or silk, is of vegetable origin, and consists of the downy material which surrounds the seeds of the plant. There are various species of the plant which produce the cotton of commerce; the chief of these are different varieties of the *Gossypium* family, a shrub growing from four to fifteen feet according to the species, and having flowers ranging in colour through the different shades of yellow to white. The *Gossypium arborum* has a red flower.

The cotton zone is said to be very extensive, and includes the “southern shores of Europe, a vast portion of Asia and Australia, two-thirds of South America, and the southern states of North America”. At present the chief supply of

cotton is obtained from North America, West Indies, Brazil, India, China, and Egypt, the fibre from different sources differing considerably in appearance and quality; the *Gos-*



A, Cotton Plant.
B, Boll.
C, Cotton Fibres, magnified.

syrium barbadense being considered one of the best, owing to its fineness and length of fibre.

Composition of Cotton Fibre

The pure cotton fibre consists of cellulose, and is composed of the elements carbon, hydrogen, and oxygen ($C_6H_{10}O_5$). The composition is similar to that of starch, the hydrogen and oxygen being present in the proportion existing in water. The following simple experiment will demonstrate the presence of the three elements:—

(B 141)

Experiment 45.—Place a small piece of clean, well-dried cotton material in a perfectly dry test-tube, and heat in a bunsen flame. The material is decomposed, water is deposited on the sides of the tube, and a black residue of carbon remains at the bottom. Thus cotton contains hydrogen, oxygen, and carbon. In the uncleansed fibre there is a fairly large percentage of impurities. Cotton wax and pectic acid are said to be the principal ones present.

Manufacture of Cotton

Before the cotton can be manufactured into yarn the seeds must be removed from the fibre. This must be done with the greatest of care, as the seeds are firmly attached to the cotton fibres, and unless carefully separated the fibres become torn, or the crushing of the seeds destroys the appearance of the cotton, and makes the cleansing of it more difficult. The operation of seed-removing is known as *ginning*, and machines by different makers are used for the purpose.

The seed has become a valuable by-product; the oil obtained by crushing it is largely used for soap-making, and also for lard, and for the adulteration of other oils. The residue is made into oil-cake, and sold as food for animals.

The cotton, free from seeds, is packed into bales and exported from the country of its growth.

The preliminary steps of mixing and cleansing have to be gone through previous to the making of the cotton into yarn.

The mixing up of different kinds of cotton is necessary to produce a yarn of good quality at the lowest price possible. By suitable blending, a cotton may be obtained which is both better and cheaper than either of the kinds separately. The cotton is then cleaned to remove all foreign matters such as dust, sand, and leaves; at the same time the fibres are opened out and made straight, ready for carding and spinning with the intermediate processes, which gradually draw the thread out and form a twist that adds to the strength and durability of the material when woven. The cotton when spun is practically ready for weaving into material, of which different qualities are produced according to the grade of cotton employed. (For Properties of Cotton, see Appendix, page 142.)

Action of Alkalies on Cotton

Caustic alkalies in solution have no detrimental effect, except that of shrinking the cotton considerably, making it closer in texture. The alkaline carbonates and soap, also ammonia, have no appreciable action on cotton.

Action of Calcium Hydrate

This substance is frequently used in bleach-works to aid in the removal of certain fatty impurities, and is said to have no injurious action unless where the fabric is exposed above the surface of the liquid, when the oxidation of the fibres is likely to take place. The lime acts on the fatty impurities of the cotton, converting them into a lime soap insoluble in water.

Action of Chlorine

If moist cotton is exposed to chlorine gas, the water in the fabric is decomposed, yielding oxygen, which in a nascent state destroys the cotton fibre. A solution of bleaching-liquid may be used successfully as a bleaching agent, and for the removal of certain stains. The solution must not be too strong nor more than $\frac{1}{2}^{\circ}$ Twaddel, and the temperature ought to be low or the quality of the fibres will also be impaired.

Action of Acids

Strong acids have a detrimental effect upon cotton. Concentrated sulphuric acid dissolves the fabric entirely, forming a gelatinous mass. Weak mineral acids do not to any extent injure cotton unless they are allowed to dry in the fabric, when they are apt to burn it.

Action of Mildew

Cotton if put away with even a small degree of moisture in it, or if kept in a damp place, and especially if there is starch in the fabric, is attacked by a species of fungi, commonly

known as mildew. This is a vegetable growth, which by a species of fermentation feeds upon and decomposes the starch, and also the fibres of the cotton, and in course of time the fibres become rotten.

Action of Frost

When cotton is exposed to frost, the fibres become hard, and unless carefully handled, and placed without folding in a warm place to soften, the material will break across, and become practically destroyed for further use. Stiffly-starched articles, when folded over, break in similar manner.

Bleaching of Cotton

BLEACHING IN SUNSHINE

Bleaching in the sun is one of the best methods of bleaching cotton, as the fibres are not in the least degree impaired; but in consequence of the length of time required to purify the material, and also the amount of labour involved, it has been superseded by a chemical process almost universally adopted in bleach-works.

To bleach in the sun the material must be thoroughly washed and boiled in an alkaline solution of soap and washing soda, then bleached for two days and two nights. The material is stretched on the grass, fastened by means of a loop of tape attached to each corner to pegs already placed in the ground. The process of boiling and bleaching must be repeated every alternate day until the fabric is quite white.

A clear frosty atmosphere charged with ozone and a bright sun are considered excellent bleaching agents.

Bleaching with Chemicals (Lime Boil).—The first step in the process of chemical bleaching is to boil in a solution of milk of lime, to decompose the natural wax and fatty impurities present in the unbleached fabric.

The calcium combines with the fatty acids, and precipitates an insoluble lime soap, calcium stearate, which is removed by subsequent processes. During the process of lime boiling,

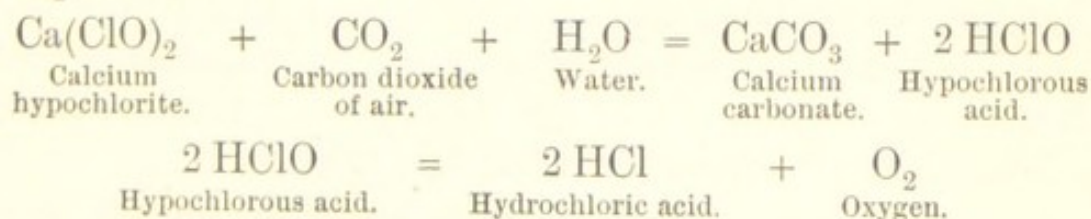
the fabric must not be exposed to steam or air, which would "tender" the fibres. This is usually overcome by placing a spraying machine in the centre of the boiler, so that continuous showers of water are passed over the surface of the material, keeping it thoroughly immersed, and thus preventing bad effects.

Acid Washing (Lime Sour).—To decompose the calcium stearate the cotton is washed through a weak solution of hydrochloric acid, which combines with the calcium, setting free the fatty acids. These are removed by the alkali during the following process.

Alkaline Bath (Ley Boil).—To remove all fatty acids and certain colouring matters, the calico is boiled in a solution of caustic soda and sodium carbonate mixed. The soda combines with the fatty acids, converting them into a soluble soap, and is removed by the water. Much of the brown colouring matter, to which the tint of unbleached calico is due, is soluble in alkaline solution, and is removed by this process. In most cases all traces of the caustic alkali are removed before passing through the chemical bath for further purification. Resin soap is also added to help in removal of the brown colouring matter.

The Chemical Bath.—A weak solution of bleaching-powder quite free from undissolved particles is prepared, and the calico passed through it, and left exposed to the air for several hours to completely destroy the yellow tint. The bleaching-liquor must not be too strong, the degree of strength varying with the quality of the material; $\frac{1}{4}^{\circ}$ to $\frac{1}{2}^{\circ}$ Twaddel is strong enough for any material.

Equation:



If too strong a solution were used it would act upon the cellulose, oxidizing it, making it "tender" and easily torn.

White Sour.—The fabric is then treated with dilute hydrochloric or sulphuric acid to remove traces of lime, unchanged bleaching-powder, and other impurities.

Finishing Process

Before the finishing touches are applied, the fabric must be thoroughly washed to remove all traces of the acid and chlorine. It is then passed through a stiffening process, to which blue is usually added. The degree of stiffness given, and the kind of blue used, depends upon the requirements of the manufacturer. If the material is wished stiff, it is generally passed through a solution of maize starch; if less stiffness is required a starch prepared from flour or gum is used instead. Frequently a mixture of the two kinds of starch is used to produce an intermediate degree of stiffness. When what is termed a soft finish is demanded, a solution of white curd, over-fatted soap, is mixed with the stiffening agent; this gives the softness in finish to the texture that is so often seen in new material.

Ultramarine blue is used to give the ordinary blue tint to cloth, but if a greenish tint is required, indigo blue is the one employed. The lengths of cloth are passed from the stiffening trough over hot rollers until the material is quite dry. It is then, if necessary, stretched to increase it in width, and beetled to flatten the fibres and close the interstices, then calendered to produce the surface gloss. After folding, it is ready for the market.

Home-Washing for Cotton

During the washing of calico at home a few points must be well kept in view if the whiteness of the material is to be retained.

First.—All dirt must be thoroughly washed out of the cotton by steeping in cold water and rubbing in hot water with soap; if very soiled a little washing soda may be added to the steeping and washing waters.

Second.—Thorough rinsing must be done to remove all traces of dirty water before putting the calico into the boiler; if the dirt were boiled into the material it would become a permanently bad colour.

Third.—Boiling for a time in soapy water removes to a certain extent discoloration from cotton, and aids in preserving the colour.

Fourth.—If there are facilities for bleaching, the material, after boiling and cooling in the soapy water, will benefit greatly if spread on the grass with the whole surface exposed to the sun.

Fifth.—After bleaching, all traces of soap should be removed by rinsing in plenty of clean water. The processes of bluing and stiffening should then be done, and the cloth if possible dried in the open air, then damped, mangled or ironed on the right side, aired, and put away until required for use.

Notes of Lesson on Cotton

Aims of Lesson—

1. To teach the source of cotton, and the action of alkalies and acids on its fibres.
2. The bleaching of cotton and the successful treatment of it in laundry work.

Apparatus—

Illustration of cotton-plant, head of ripe cotton, and two pieces of the woven material (bleached and unbleached). Test-tubes, bunsen burner, caustic soda, chlorine in solution, sulphuric acid, acetic acid or vinegar, mildewed cotton, starch, gum water, black-board, easel, chalk and duster. Soap.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Illus. 1. —Show illustration of cotton-plant and head of cotton, some raw cotton, and a piece of calico.	Obs. 1. —The cotton ball is composed of white downy substances. The raw cotton is similar in appearance.	Inf. 1. —Calico is of vegetable origin, and is prepared from the cotton-plant.
	Sugg. 1. —Cotton is imported from North America, West Indies, Brazil, India, China, and Egypt.	Inf. 2. —Cotton grows most successfully in warm climates.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 1. —Place a piece of dried cotton in a well-dried test-tube, and heat in bunsen flame, and pass the evolved gases into lime-water.	Obs. 2. —Water is deposited on sides of test-tube, the cotton becomes black, and lime-water becomes turbid (indicating presence of carbon dioxide).	Inf. 3. —Carbon, hydrogen, and oxygen are present in cotton.

The teacher should here explain the manufacture of cotton.

Exp. 2. —Put a piece of cotton into a solution of caustic soda and leave for a time, then remove, and pull between the hands.	Obs. 3. —The cotton has slightly shrunk and feels rather sticky, but does not tear readily on pulling.	Inf. 4. —Caustic alkalies shrink cotton, but do not seem to impair the fabric.
Exp. 3. —Steep a piece of cotton for a time in a solution of chlorine, remove, and pull between the hands.	Obs. 4. —The fabric easily pulls to pieces.	Inf. 5. —Chlorine destroys cotton fibres.
Exp. 4. —Put a small piece of cotton into strong acid.	Obs. 5. —The fabric is dissolved.	Inf. 6. —Strong acids destroy cotton.
Illus. 2. —Show a piece of cotton with mildew stains on it.	Obs. 6. —The material is covered with dark round spots. Sugg. 2. —Mildew is a vegetable growth that appears on cotton when it is left for a time damp.	Inf. 7. —Cotton should not be put away damp, as black spots of mildew develop on the fabric and tend to destroy it.
Exp. 5. —Fold a piece of stiffly-starched cotton, and if possible a piece of hard-frozen cotton material.	Obs. 7. —The fibres break.	Inf. 8. —When cotton is hard with starch or frost it becomes brittle, and easily breaks. It must therefore be softened before folding.
Illus. 3. —Show a piece of material that has been washed, boiled, and bleached in the sun, and a similar piece that has not been bleached.	Obs. 8. —The piece that has been bleached is whiter than the other.	Inf. 9. —Sunshine bleaches cotton.

The teacher should here explain the bleaching of cotton professionally.

Experiments and Illustrations.	Observations and Suggestions.	Inferences.
Exp. 6. —Place a piece in a weak solution of bleaching-powder, and leave for a time.	Obs. 9. —Calico becomes whiter.	Inf. 10. —Bleaching-powder destroys the colouring matter in calico.
Exp. 7. —Place another piece of calico in strong solution of bleaching-powder, and leave exposed to the air.	Obs. 10. —Calico becomes “tendered” or oxidized, and falls to pieces.	Inf. 11. —Bleaching-powder destroys fabric, and ought to be used with care.
Exp. 8. —Stiffen a piece of cotton in hot starch, another piece in starch mixed with soap, and another in gum-arabic solution.	Obs. 11. —All are stiff. The one done in starch only is stiffer than the other two; the one done in soap and starch is soft to feel.	Inf. 12. —Starch stiffens fabric. Soap helps to reduce the stiffening property. Gum gives less stiffness.

Black-board Summary

COTTON

Sources:—

Cotton is of vegetable origin, obtained from the cotton-plant. Grown in America, West Indies, Brazil, India, China, and Egypt.

Composition:—

Carbon, hydrogen, and oxygen.

Action of caustic alkalies on cotton:—

The fabric shrinks, but the fibres are not appreciably impaired.

Action of acids on cotton:—

The fabric is destroyed by strong acids.
Weak acids have no action.

Action of chlorine on cotton:—

The fabric is bleached and fibres tendered.

Action of sunshine on cotton:—

It destroys colouring matter, and bleaches the cotton.

Action of starch on cotton:—

The material becomes stiff, and the appearance is improved.

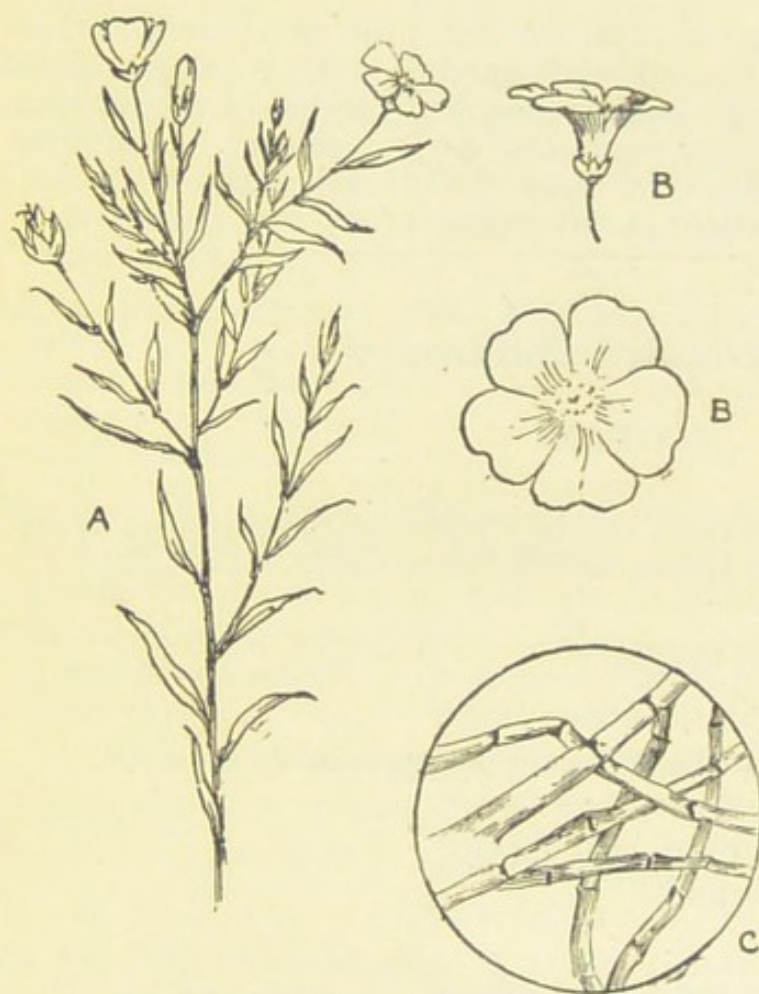
CHAPTER XX.—FLAX

The flax-plant as cultivated is an annual, and grows from 20 to 40 inches high, branching towards the top, and each branch capped with a bright-blue flower.

The plant belongs to the natural order of Linaceæ, of which there are numerous varieties, *Linum usitatissimum* being the flax of commerce.

The cultivation and use of flax extends to a very remote period in the world's history, and is one of the most ancient of textile industries.

Flax is cultivated in most parts of Europe, and to obtain successful crops the soil must be evenly rolled and free from lumps, the seed closely sown, to enable the stalks to grow straight and even in fibre. To produce a good fibre the growing plant



A, Flax Plant. B, B, Blossoms. C, Flax Pibres, magnified

should be carefully watched and pulled by the root when two-thirds of its stem becomes yellow, after which it must be dried, and the seeds removed, when it is ready for the process of separating the fibres from foreign matter and the woody stem. The finer fibres towards the top of the plant are utilized for fine material, while the thicker ones nearer the root are used for the manufacture of coarser fabric.

“ Retting ”

The process known as “retting” or “steeping” of the fibre ought to be most carefully done to prevent decomposition of the fibres. There are two methods of retting—cold water, and dew retting. The former process is as follows:—The bundles of flax are packed in crates lined with straw, and the top covered with straw and board; they are then placed in water and weighted, to prevent them floating above the surface. In a few days fermentation sets in, and acts on the gummy products contained in the stem; as the gas escapes, additional weight must be added to keep the crates submerged. The retting may continue from ten to twenty days, according to the temperature of the air and water, and the quality of the flax, and also the quality of the water. If fresh water is used, soft is the best, hard water being quite unsuitable. Stagnant water is often employed, as it renders the process more expeditious, owing to the organic matters present assisting in the fermentation. When steeping in stagnant water the flax must be carefully examined from time to time, in case of the fermentation becoming too energetic and attacking and destroying the fibres. When the fibres become quite soft and separate easily from the woody stem, the flax is removed from the water and placed in loose sheaves or straightened on the grass to dry. This takes about a week; during that time the dew, air, and sun help to complete the process of purification.

Dew Retting.—This process consists of spreading the flax on the grass, and leaving it for about two months until all the adhesive substances are removed by the action of rain, sun, and air. Wet weather is best for this process, as water is necessary to produce fermentation. After drying, the woody centre is broken by passing the flax through a machine with fluted rollers and removed by beating the fibres with a large wooden blade.

The flax is further cleaned and combed, to separate the tow from the flax line. It is then ready for spinning and other finishing processes.

Composition of Flax Fibre

The flax fibre when pure, like that of cotton, is principally composed of cellulose ($C_6H_{10}O_5$), and in consequence contains carbon, hydrogen, and oxygen; but when in the raw unbleached condition, it is charged with a large amount of pectic acid, also colouring and fatty matters, probably formed during fermentation, all of which are removed by bleaching.

A simple experiment, similar to that done to prove the presence of the different elements in the cotton fibre, may be successfully performed with a piece of linen. (See page 130.)

Properties of Linen

Linen when purified is snowy-white in appearance, it has a glossy surface, and is of great strength. It is a better conductor of heat than cotton, and feels colder to the touch in consequence.

Action of Alkalies, Acids, &c., on Linen

Linen being of the same composition as cotton, the various chemicals have a similar action on its fibre as on those of cotton, and need not again be described (but it is said "linen is more susceptible to the influence of oxidizing agents, and is more readily destroyed").

Bleaching and Finishing

As the bleaching and finishing processes are exactly the same as those for cotton (see pages 132 and 134), repetition is needless. But there is one point of difference which may be stated. As raw linen is much darker in colour than cotton, merely passing through the chlorine bath is not enough to remove the colouring matter; it is therefore necessary to steep the material for a number of hours in the chemical bath. The flax fibre is similar in composition to that of cotton, and the action of the different chemicals and the method of bleaching are the same as those described in notes of lesson on cotton. Repetition is also in this case unnecessary.

APPENDIX

Chlorine Gas as a Disinfectant

Chlorine gas is a powerful disinfectant, and is frequently employed for the purification of infected rooms. It is usually generated by the action of strong sulphuric acid on common salt, with the addition of manganese dioxide, without which the chlorine would not be liberated. Two ounces of each of the above-named substances mixed in a porcelain vessel, and slightly heated, will liberate a volume of gas capable of disinfecting 1000 cubic feet of space.

The greatest objection to the use of chlorine gas as a fumigating agent is its strong bleaching property. It oxidizes the colouring matter in wall papers, carpets, hangings, and window blinds, and in some cases the paints on furniture; so that, although a thorough disinfectant, it is rejected by many people in favour of a substance which will kill germs without destroying colour.

Formalin as a Disinfectant

Methyl alcohol is commercially obtained by the destructive distillation of dried hard woods, such as birch and beech. This when passed over platinum wire is changed into formaldehyde, which is by a certain process converted into a solid substance known and sold as formalin, and frequently sold in a tablet form. This is used as a disinfectant for leather goods, and furs, and articles that cannot be treated successfully by any other method.

It is also employed for the fumigation of rooms, and is considered superior to all other gaseous disinfectants, because it is said to have a strong germicide power, and at the same time does not act destructively on carpets or clothing, nor does it tarnish or corrode metals as is the case when most chemical disinfectants are used.

Method of using Formalin.—When a room and its contents are to be disinfected, all closet doors and drawers must be

opened, the clothing and bedding exposed as much as possible; the window should then be made tight, and after the light is applied to the fumigator the door of the room must be tightly closed.

A number of the tablets of the formalin should be placed in a vessel and put over a spirit lamp. The solid is decomposed, with the evolution of formaldehyde gas, which permeates the different substances and destroys the germs.

Thirty tablets weighing 1 gram each is said to thoroughly disinfect 1000 cubic feet of space.

Properties of Silk

Silken fibres have the property of absorbing water, although to a less degree than those of wool, yet more so than cotton or linen; and also, like wool, silk parts with the moisture slowly, and thus by slow evaporation the rapid reduction of the temperature of the body is prevented.

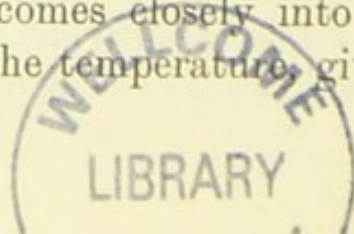
Silk is also a bad conductor of heat, especially if loosely woven, which permits of the air being held in the spaces, and prevents the heat of the body passing away.

Silk is soft, light, and lustrous, and in most cases it has a crisp sound or "scroop".

Properties of Cotton

Cotton is a strong, durable, and, in a natural state, cream-coloured material. It is fine and firm in texture; this property prevents it holding air in its meshes, and also increases its power of conduction, and adds to its disadvantages as an article of clothing.

Cotton easily becomes saturated, because its fibres have not the power of absorbing moisture to the extent of those of wool. The water in consequence is held in the interstices between the fibres of the cotton, and can easily be squeezed out of the material. Water is a good conductor of heat; so when cotton is moist, and it comes closely into contact with the body, it rapidly reduces the temperature, giving sense of chill.



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