

A syllabus of the courses of lectures on chemistry, delivered in King's College, London / [J. Frederic Daniell].

Contributors

Daniell, J. Frederic (John Frederic), 1790-1845
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MEDICAL SOCIETY
OF LONDON



ACCESSION NUMBER

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James Wilkes
1833





*The Medical Society of London
presented by D^r John Davidson, 1832*

SYLLABUS

OF

THE COURSES OF LECTURES

ON

CHEMISTRY,

DELIVERED IN

KING'S COLLEGE, LONDON.

BY

J. FREDERIC DANIELL, F.R.S.

PROFESSOR OF CHEMISTRY IN KING'S COLLEGE.



LONDON:

B. FELLOWES, BOOKSELLER & PUBLISHER TO THE COLLEGE,

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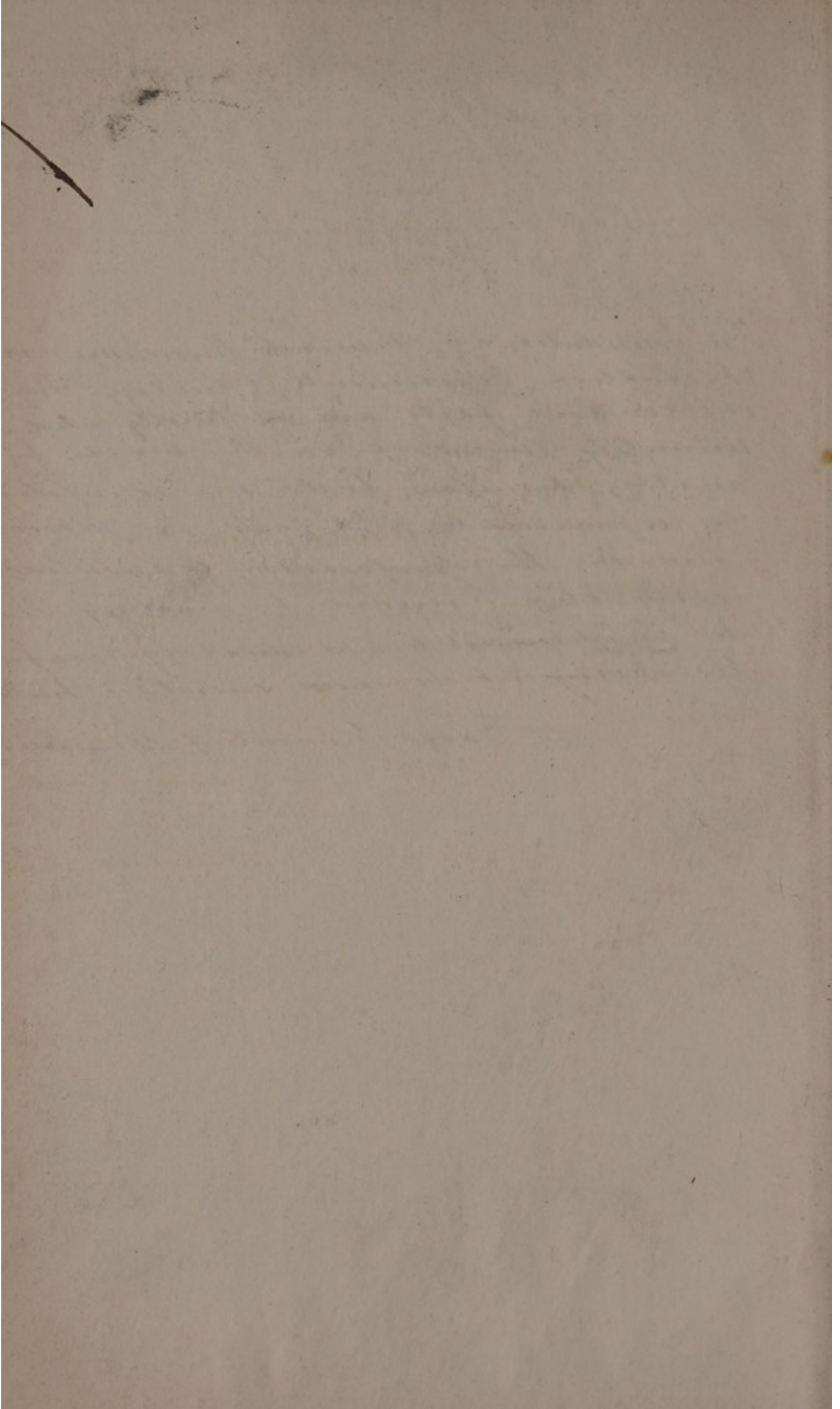
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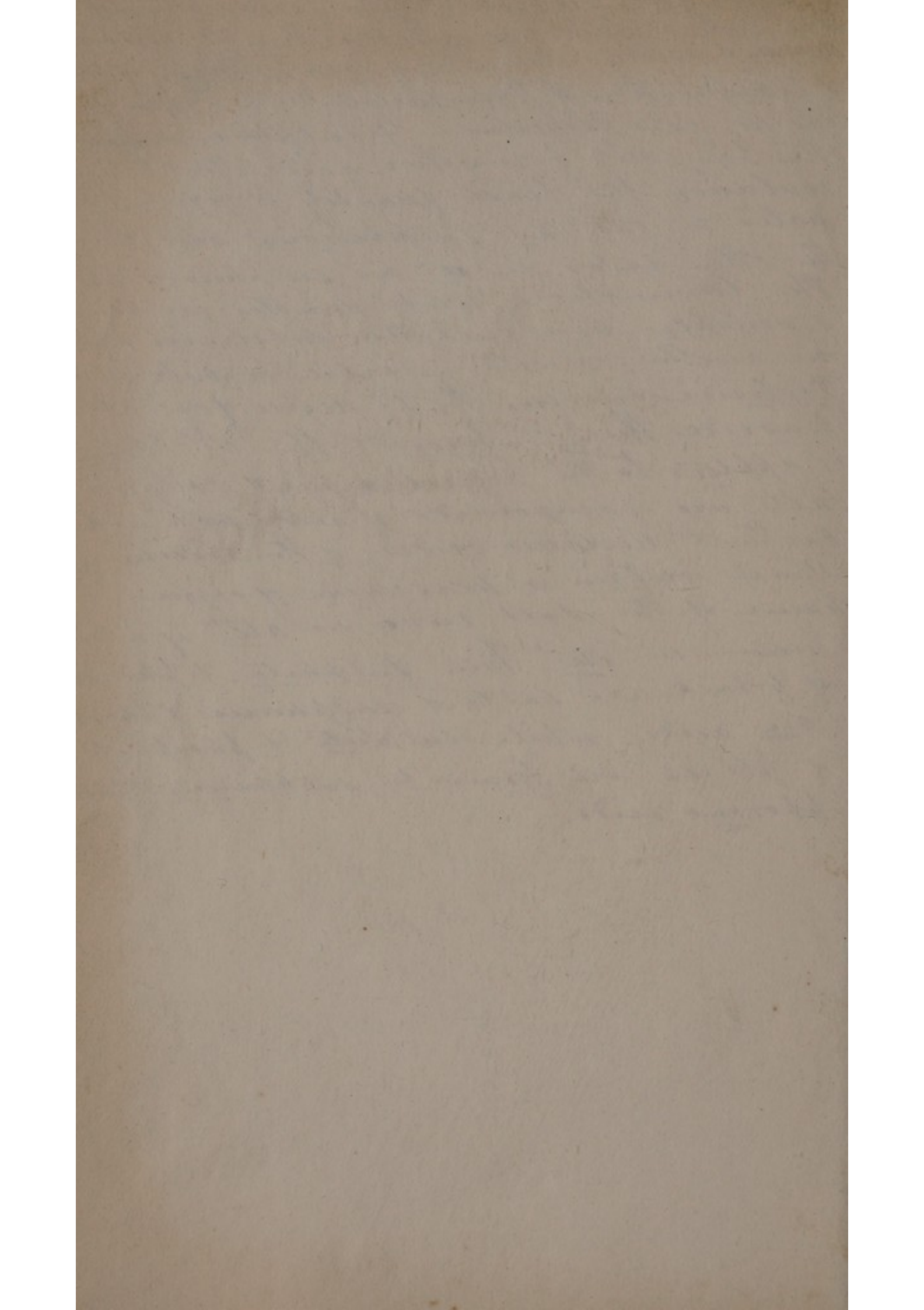
“ Science is the knowledge of many, orderly and methodically
digested and arranged, so as to become attainable by one.”—
HERSCHEL'S *Discourse on the Study of Natural Philosophy*,
p. 18.

"The foundations of chemical knowledge are observation, experiment, & analogy. By observation, facts are distinctly and minutely impressed on the mind; by analogy, similar facts are connected. by experiment new facts are discovered. and in the progression of knowledge, observation, guided by analogy, leads to experiment, and analogy, confirmed by experiment, becomes scientific truth."

Davy's Elements of Chemical Philosophy



Compounds of which Oxygen forms a part
are called acids or oxides as they do or do not
possess acidity. An oxide of iron or copper signifies
a combination of those metals with oxygen which
has no acid properties. If sulphur or any
other body sh^d form two acids that which
contains the least quantity of oxygen termi-
nates in "ous" as sulphurous acid, while
the other ends in "ic" as sulphuric acid.
The termination "uret" denotes combination
of simple non metallic substances with
one another, or with a metal or metallic oxide.
Protoxide signifies the 1st degree of oxidation,
binoxide the 2nd peroxide the 3rd. Peroxide
is applied to the highest degree of oxidation.
Salts are compounds of acids with alkaline
earth, or metallic oxides. If the acidified sub-
stance contain a maximum of oxygen, the
name of the salt ends in "ate" if a mini-
-mum in "ite". Thus Sulphate, & phosphate
of potash are salts of sulphuric & phospho-
-ric acids, while sulphite & phosphite
of potash are formed by sulphurous & phos-
-phorous acids.



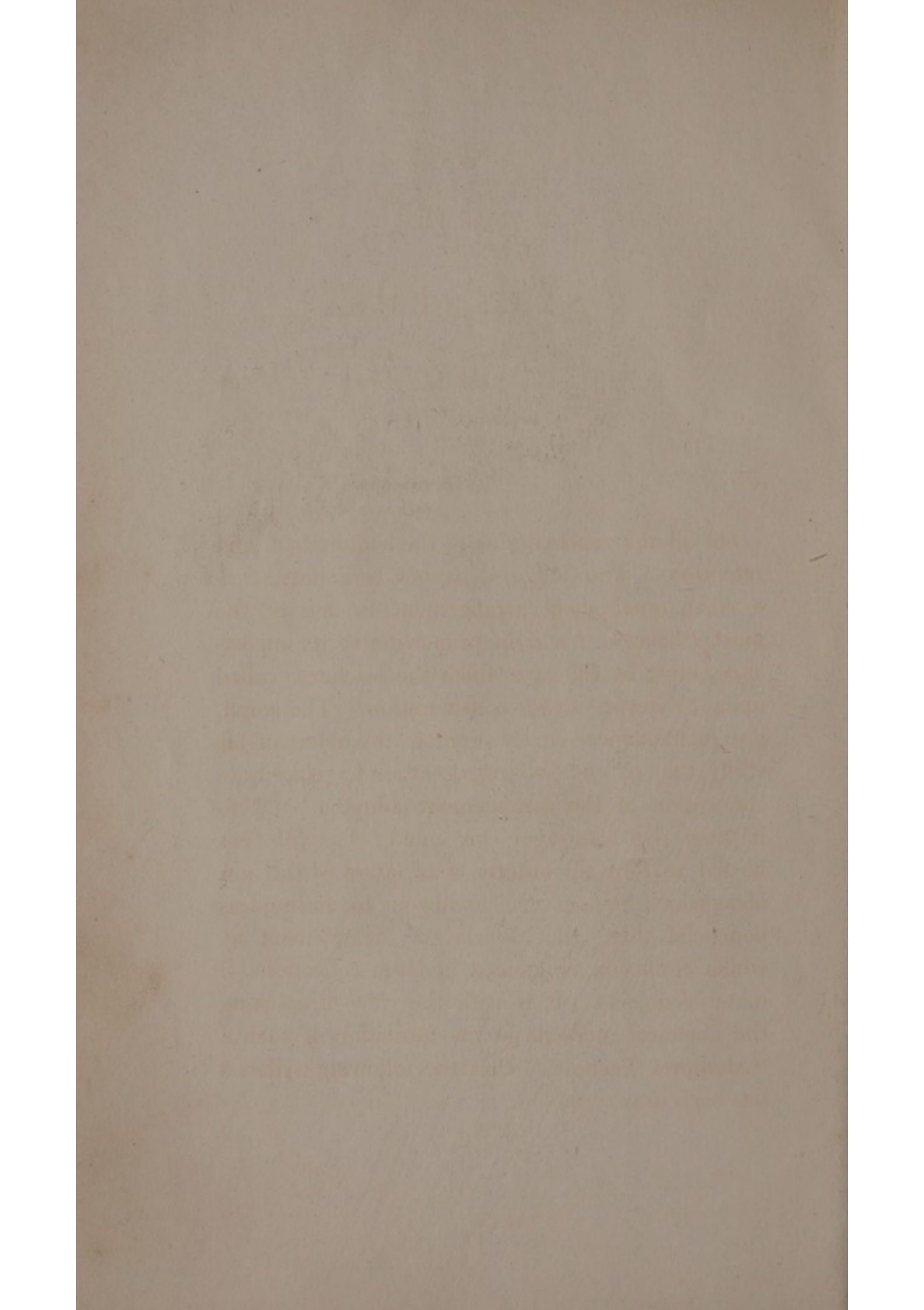




SYLLABUS

1884

The following is a list of the subjects which will be covered in the course of study during the year 1884. The subjects are arranged in the order in which they will be taken. The subjects are: 1. English Literature, 2. History, 3. Geography, 4. Natural Science, 5. Mathematics, 6. Music, 7. Art, 8. Physical Education, 9. Social Science, 10. Languages, 11. Modern History, 12. Ancient History, 13. Philosophy, 14. Political Science, 15. Economics, 16. Law, 17. Medicine, 18. Agriculture, 19. Engineering, 20. Architecture, 21. Fine Arts, 22. Music, 23. Drama, 24. Poetry, 25. Prose, 26. Verse, 27. Fiction, 28. Non-fiction, 29. Biography, 30. Autobiography, 31. History, 32. Geography, 33. Natural Science, 34. Mathematics, 35. Music, 36. Art, 37. Physical Education, 38. Social Science, 39. Languages, 40. Modern History, 41. Ancient History, 42. Philosophy, 43. Political Science, 44. Economics, 45. Law, 46. Medicine, 47. Agriculture, 48. Engineering, 49. Architecture, 50. Fine Arts, 51. 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A SYLLABUS,

&c. &c.

OF all the artificial aids to the acquirement and retention of knowledge, it cannot be doubted that a clear, methodical arrangement is one of the most efficacious; and in proportion to its importance, must be the care which the teacher is called upon to devote to its consideration. The pupil, also, cannot more surely promote the object of his study, than by endeavouring to attain to an accurate conception of the arrangement adopted, and to impress the plan upon his mind: he will thus be led to form an orderly distribution of the new ideas which he acquires; analogous to, and no less beneficial than, that species of arrangement by which confusion is avoided in large collections of material objects. It is with the view of assisting the chemical students in the formation of such a "Memoria Technica" that the following syllabus has been drawn up.

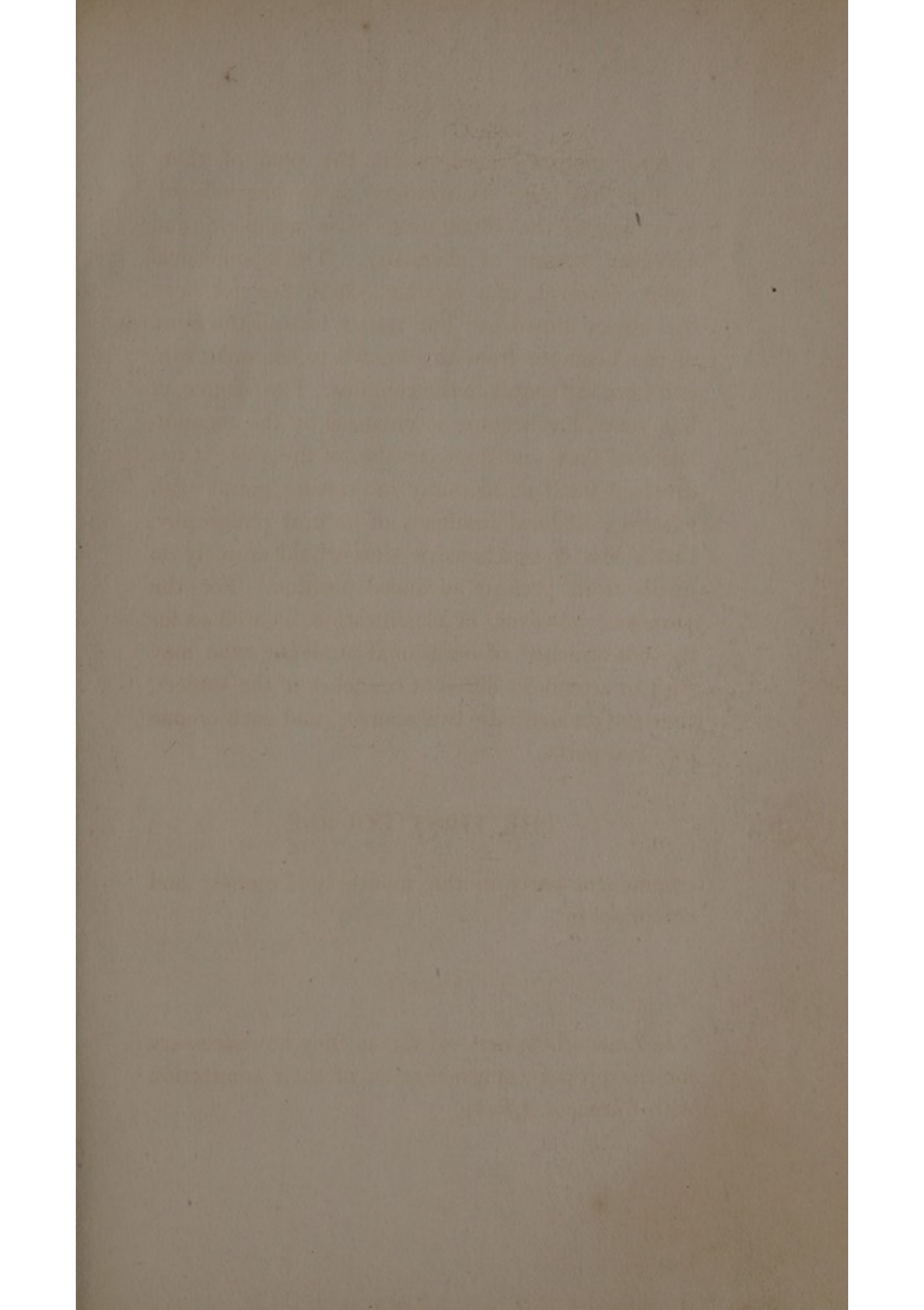
After mature consideration, the plan of these lectures has been so arranged as to comprehend, as a whole, the illustration of a complete and extended system of chemistry. The symmetrical order, however, of a regular system has not been the object aimed at; but rather to lead the mind of the beginner from the known to the unknown, and from the simple to the complex. The science, of late years, has become so enlarged by the accumulation of facts and the extension of theories; it has involved itself at so many interesting points with various collateral branches of natural philosophy, that a less comprehensive view would scarcely do justice to its present advanced position. For the purposes, however, of classification, as well as for the convenience of occasional students, who may wish to attend to different branches of the subject, they are divided into two courses, and each course into two parts.

THE FIRST COURSE

commences early in the month of October, and comprises in

PART I.

The Laws of Physics—so far as they are necessary for the proper comprehension of their connection with *Chemical Affinity*.



There is a great deal of talk about the
importance of the study of the history of
the world. It is true that the study of
the history of the world is important, but
it is not the only thing that is important.
There are many other things that are
important, and they are all part of the
study of the world. The study of the
world is a very broad field, and it
includes many different subjects. It is
not just the study of the past, but
also the study of the present and the
future. The study of the world is a
very important part of our education,
and it is one that we should all be
interested in. It is a study that
helps us to understand the world around
us, and it is one that we should all
be proud to study.

THE HISTORY OF THE WORLD

The history of the world is a very broad
field, and it includes many different
subjects. It is not just the study of
the past, but also the study of the
present and the future.

Page 100

The study of the world is a very
important part of our education, and
it is one that we should all be
proud to study.

The first volume of the series, which
contains the history of the
country from the first settlement
to the present time.

Part II

The second volume of the series, which
contains the history of the
country from the first settlement
to the present time.

THE HISTORY OF THE COUNTRY

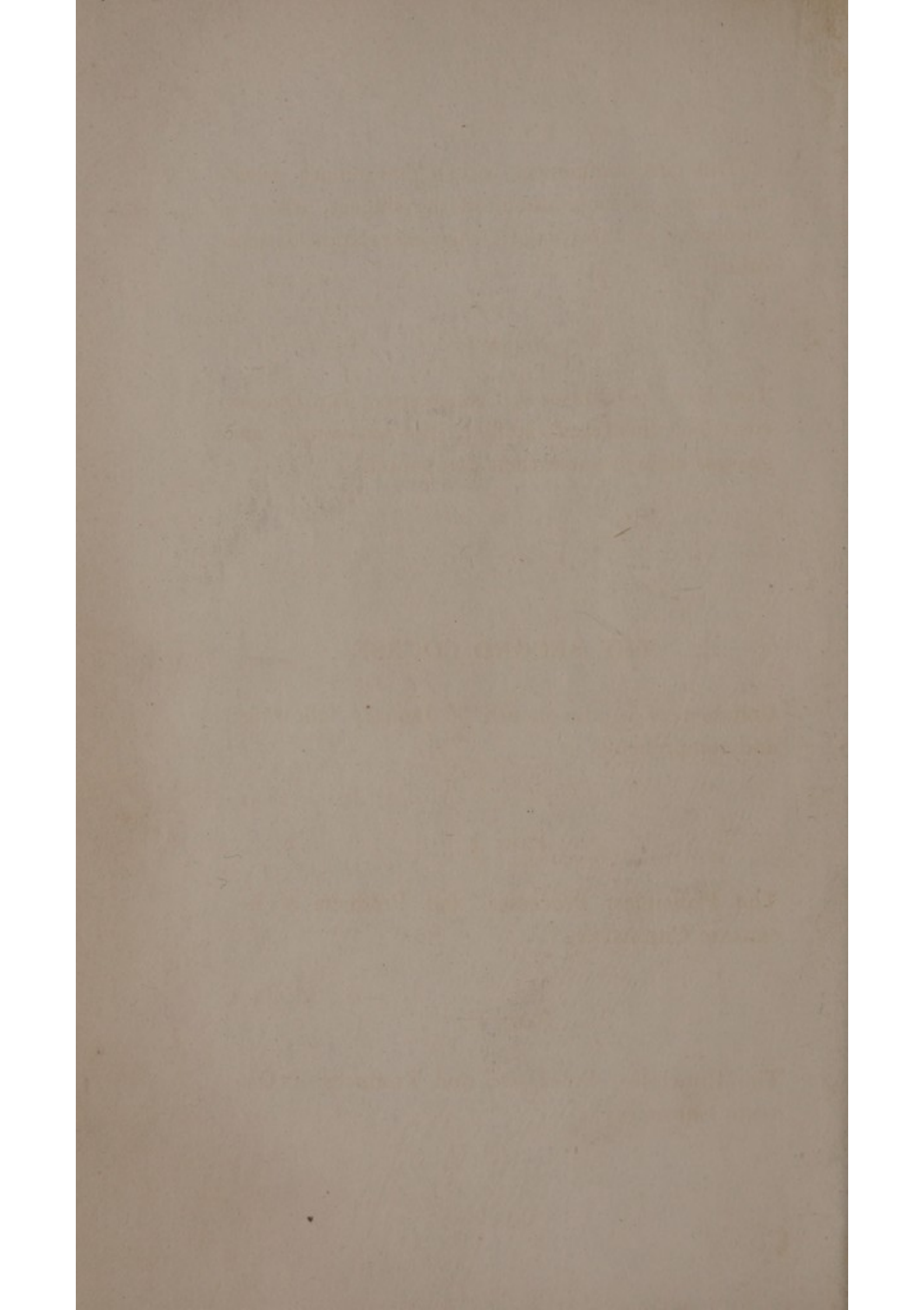
The third volume of the series, which
contains the history of the
country from the first settlement
to the present time.

Part I

The first volume of the series, which
contains the history of the
country from the first settlement
to the present time.

Part II

The second volume of the series, which
contains the history of the
country from the first settlement
to the present time.



This part commences with a preliminary *mechanical* view of each branch of the subject, which is succeeded by their strictly *chemical* relation to each other.

PART II.

THE LAWS OF CHEMICAL COMBINATION AND DECOMPOSITION; illustrated chiefly by the *non-metallic* and *gaseous* elements and their compounds.

THE SECOND COURSE

Commences in the month of January following; and comprehends in

PART I.

The Principles, Processes, and Products of IN-ORGANIC CHEMISTRY.

PART II.

The Principles, Processes, and Products of ORGANIC CHEMISTRY.

It is a primary object of these Lectures not only to verify the results of reasoning by experimental illustration, but to elucidate the phenomena of nature, and explain the combinations of art in the processes of the Pharmacopœia, of metallurgy, of the principal manufactures, and of domestic economy.

At convenient intervals of the courses, EXAMINATIONS are held; at which regular students, who require certificates, are expected to attend. They are not instituted so much for the purpose of exciting emulation, as of affording opportunities of familiar and conversational elucidations of the more difficult parts of the science, and of the explanation of points which may have been misunderstood. For this reason, the occasional students, also, are recommended to be present; and, although they will not be required to take a part in them, the names of such as wish to avail themselves of the full advantage which they offer, will be received by the Professor.

To enable the students of the mathematical and classical departments of King's College to attend these lectures, without interfering with their other studies, they have been fixed for 9 o'clock in the morning.

Matter though susceptible of motion
has no power either to move itself, or
arrest its progress when an impulse
is once communicated to it. This
indifference to rest or motion has
been expressed by the term vis iner-
tia, as if it depended on some
specific force resident in matter;
but it may with greater propriety
be regarded as a negative character
in consequence of which matter is
wholly given up to the operation of
various forces which are constantly
acting upon it.

All bodies descend in straight lines towards the centre of the Earth when left at liberty at a distance from its surface. The power which produces this effect is termed gravity, the attraction of gravitation, or terrestrial attraction, and the force required to separate a body from the surface of the Earth, or prevent it from descending towards it is called its weight. Every particle of matter is equally affected by gravity, and therefore the weight of any body will be proportional to the number of ponderable particles it contains. The tendency of cohesion is manifestly to bring the ultimate particles of bodies into immediate contact; & such m^t be the result of its influence were it not counteracted by an opposing force, a principle of repulsion, which prevents their approximation. The form of bodies as to solidity & fluidity is determined by the relative intensity of these powers. Cohesion acts at insensible distances, & between similar particles, chemical attracⁿ between dissimilar ones. Thus marble is an aggregate of smaller portions attached to one another by cohesion, but these integrant particles are composed of lime & carbonic acid which are united by affinity.

First Course.

PART I.

§ THE LAWS OF PHYSICS.

I. INTRODUCTORY REMARKS.

1. *Inertia of Matter.*
2. *Force.* (a) Origin of the idea. (b) Animal force. (c) Weight. (d) Elasticity. (e) Motion. (f) Equilibrium. (g) Attraction. (h) Repulsion.
3. *Gravitation.*
4. *Elasticity.*
5. *Cohesion.* (a) Capillary action.
6. *Heat.* (a) Sensation. (b) Expansion.
7. *Electricity.* (a) Attraction. (b) Repulsion.
8. *Magnetism.* (a) Attraction. (b) Repulsion.
9. *Chemical Affinity.*

II. GRAVITATION.

1. *Weight.* (a) Balances. (b) Mode of weighing. (c) Torsion balances.
2. *Specific Gravity.* (a) Of solids. (b) Liquids. (Hydrometers.)

III. ELASTICITY.

1. *Gases.* (a) Mechanical properties. (b) Barometer. (c) Air pump. (d) Air gun.
2. *Manipulation of Gases.* (a) Collecting. (b) Measuring. (c) Weighing. (d) Specific gravity.

IV. ATTRACTION OF COHESION.—V. REPULSION OF HEAT.

PHYSICAL STATE OF BODIES.

1. *Solids.* (a) Hardness. (b) Elasticity. (c) Brittleness. (d) Malleability. (e) Ductility. (f) Tenacity.
2. *Liquids.* (a) Slight compressibility. (b) Viscosity. (c) Limpidity.
3. *Aeriform Fluids.* (a) Gases. (b) Vapours. (c) Condensation.

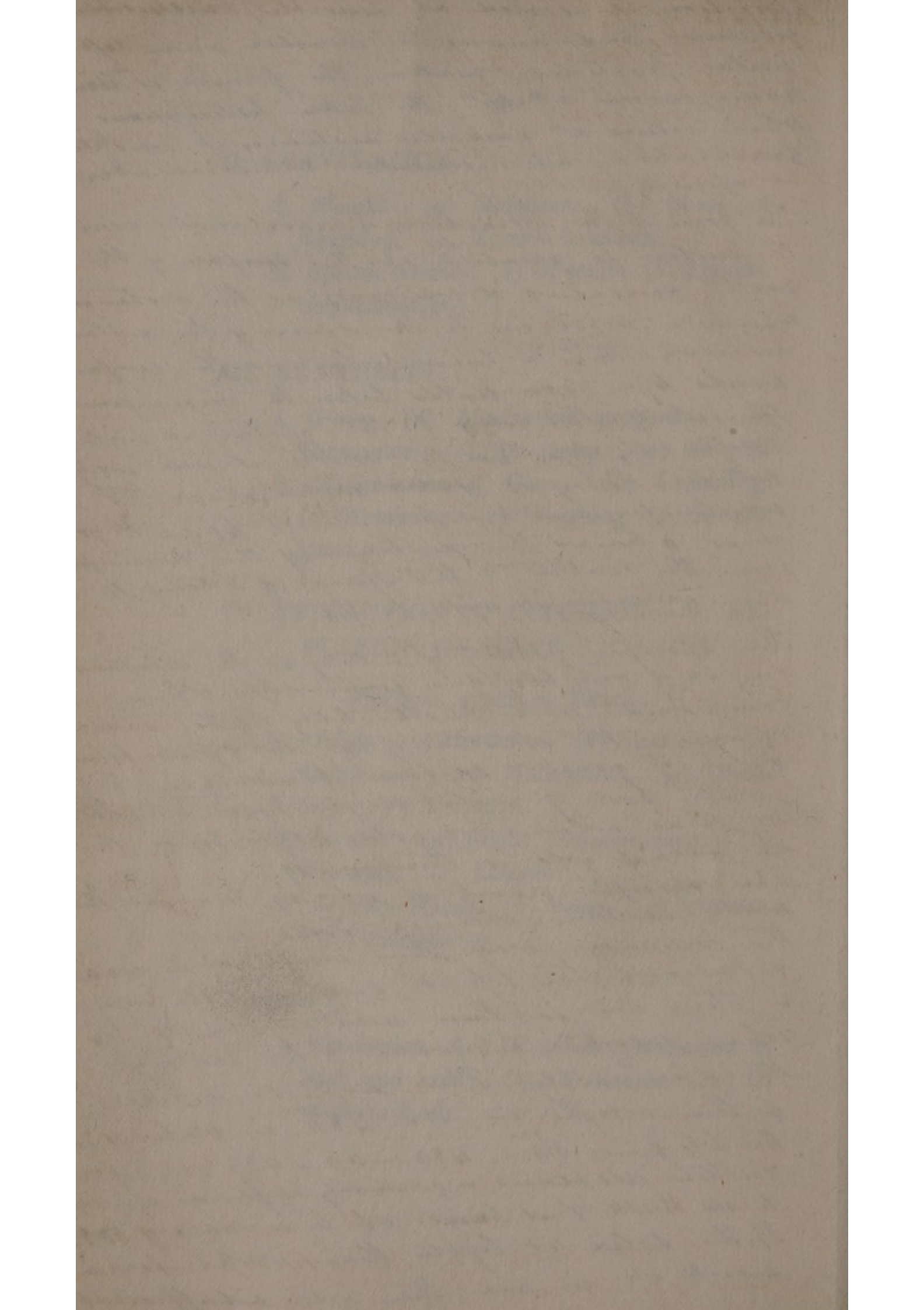
V. HEAT.

1. *Conduction.* (a) Of solids. (Sensation of heat and cold) (b) Of liquids. (c) Of aeriform fluids.

Attraction is exerted at sensible & insensible distances, and among the similar and dissimilar particles of matter, the former is termed homogeneous attract. the latter heterogeneous. When acting at sensible distances it constitutes gravitation; at insensible, chemical attract. or affinity.

The force of the attraction of gravitation accord. to Newton is greatest at the surface of the earth, decreasing downwards as the distance, upwards according to the square of the distance inversely: thus, a piece of lead on the surface weighs 4 $\frac{1}{2}$ 2000 miles below the circumference being half the way to the centre it will weigh only $\frac{1}{4}$ at the centre it will weigh nothing. Carry it 16000 miles above the circumference & it will weigh $\frac{1}{16}$ of a lb. for it is 16 times the distance of the circumference from the centre, & the square of 4 being 16 when inverted it will be $\frac{1}{16}$.

The specific gravity of a body is the relative weight of any body of a given size when compared with another body of the same volume, the standard of solids & fluids being water, of gases & aëiform fluids air. E.g. 1 cubic foot of water weighs 7000 whilst the same volume of gold weighs 70000. The sp. grav. of gold is therefore 10.
The specific gravity of a body heavier than water is thus obtained. First weigh it in the common way, then weigh it in water. The loss it sustains its weight in the air is then divided by its loss when weighed in water & the product is the sp. gravity. Thus suppose a piece of tin weighs in air 480^{grs.} in water 430^{grs.} the loss being 50^{grs.} $480 \div 50 = 9\frac{3}{5}$ sp. gr. of tin. The tin displaces a quantity of fluid equal to its bulk & is buoyed up by a weight of 50^{grs.} If the solid is lighter than water first weigh it in air, then add a sufficient



weight to cause it to sink entirely below the surface of the water; then divide the weight of the substance by the weight added to the weights required to sink it and the quotient is the sp. grav. E.g. a piece of cork weighs 30 gr. & requires 150 gr. of metal to sink it, then $30 \div (150 + 30 =) 180 = .166$ sp. gr. of cork — The sp. gr. of fluids is generally taken by the hydrometer: the lighter the fluid is deeper does the instrument sink, thus in brandy it sinks to 25, therefore if water be 1000 brandy w^d be 975 — 60° is the temperature at which bodies are usually taken. By substituting spirits of wine or any liquid for water in the 1st experiment, its sp. gr. may be ascertained: thus in spirit it sinks 149^{ms} — to support the glass while in water it took 177^{ms} we say then as $177.5 : 149 :: 1 =$ loss of weight in water & the quotient is its sp. grav. The sp. gr. of elastic fluids is then obtained: exhaust the air from a thin flask & weigh it accurately: put it on a receiver on which the cubic inches are marked: fill the flask with the gas & ascertain the quantity which enters it, and then again weigh it. The density of the atmosphere is of importance in weighing gases, & it is necessary to a standard elasticity, & that fixed upon is 30 inches. — If you want to know the sp. gr. of a gas at a different state of the atmosphere, say if the gas were 31^{ms} & the barometer 29^{ms} state, as $30 : 29 :: 31 = 29\frac{9}{10}$ —

The pressure of the atmosphere is 15 lbs. on every square inch: it is this pressure which prevents liquids assuming the elastic form or boiling & we can retain them in its liquid state. Water put under the receiver of the air pump boils on the atmospheric pressure being removed.

Heat. The most general effect of heat is repulsion
or expansion by which heat separates the particles of bodies.
It is the antagonist power of attraction. Some suppose
that it is a peculiar fluid, others that it is merely
produced by the motion of the particles of bodies
upon each other. The sources of heat are The sun,
percussion & friction, the mixture of bodies, com-
bustion of bodies & Electricity. Heat & cold when
referred to our sensations depend on the tempera-
ture of our bodies at the time of the experiment.
The different conducting powers of bodies ~~depend~~ ^{cause}
different sensations of heat or cold; a good con-
ductor conducts heat rapidly from the hand &
causes coldness: the best conductor is silver then
gold, copper, brass, iron, tin, cast iron, Zinc, lead,
dense stones, brick, pottery, glass charcoal. The
latter is a very bad conductor. Diamond is better
than glass, & so on applying the tongue to it it
may be distinguished from glass from its greater
coldness. Glass is a bad conductor of heat &
this causes the fracture of glass on applying
hot water: if hot water be poured into a glass of
moderate thickness the inner surface expands
while the outer remains unaltered & fracture
necessarily takes place. Liquids are very
bad conductors of heat: in the usual
mode of heating liquids the heat is
applied to the bottom of the fluid &
is diffused over the whole mass in con-
sequence of the successive changes of
density in the particles, the specific gr.
of the heated particles being decreased vis-
to the top of the fluid & a complete cir-
-culation is established. If heat be
applied to the surface of water it can
only be propagated by its conducting power
no interchange of particles takes place.
This is proved by an air thermometer in
a vessel of water not being influenced by
heat being applied to the surface by means
of a small copper basin containing inflamed
ether, although the surface is at the boiling point.
Air & gaseous bodies are also very bad
conductors of heat. A stratum of confined
air is a very bad conductor: hence the
advantage of double doors to rooms, fur-
-naces, ice houses &c. Air may be heated
to 300° & yet a person may remain in it with

The intensity of radiation diminishes according to the square of the distance from the radiating point.

2. *Expansion.* (a) Of solids. (b) Liquids.
(c) Aeriform fluids.

A. THERMOMETERS. (a) Air thermometer. (b) Differential. (c) Mercurial. (d) Spirit. (e) Graduation. (f) Register.

B. PYROMETERS. (a) Wedgwood's. (b) Daniell's.

C. Standards of Specific Gravity. (a) Correction for Expansion.

3. *Exceptions to the Law of Expansion.* (a) Congelation. (b) Max. density of water.

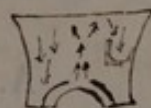
4. *Equilibrium of Heat.* (a) By conduction in solids. (b) Circulation in fluids. *Perkins' boiler*

A. Circulation of the Atmosphere.

B. ————— Ocean.

C. Ventilation of Apartments

D. Warming of Apartments.



VI. CRYSTALLIZATION. (a) Formation of crystals. (b) Nuclei. (c) Peculiar forms. (d) Primitive forms. (e) Secondary forms. (f) Structure. (g) Cleavage. (h) Goniometers.

1. *Hypothesis of Polyhedral Atoms.* (a) Primitive forms. (b) Secondary forms. (c) Decrements upon edges. (d) Decrements upon angles. (e) Octohedral and tetrahedral atoms.

2. *Hypothesis of Spheroidal Atoms.* (a) Spheres, octohedral and tetrahedral arrangement identical. (b) Oblate spheroids. (c)

The sources of Caloric are 1. The Sun - 2 Combustion - 3 Electricity - 4 The bodies of animals during life - 5 Chemical action - 6. Mechanical action

oblong spheroids. (*d*) Dr. Wollaston's structure of the cube.

A. DISSECTION OF CRYSTALS.

- (*e*) More probable structure of the cube. (*f*)
- Octohedral structure of the cube. (*g*)
- Cubic structure of the octohedron.

B. UNEQUAL EXPANSION OF CRYSTALS.

3. *Hypothesis of the Atmospheres of Atoms.*

- (*a*) Explanation of unequal expansion.

VII. ELECTRICITY. A. Electricity of Tension.

B. Current Electricity.

A. ELECTRICITY OF TENSION. (*a*) Attraction. (*b*) Repulsion.

- 1. *Electrical Theories.* (*a*) Du Fay's. (*b*) Priestley's.
- 2. *Conduction.* (*a*) Conductors. (*b*) Non-conductors. (*c*) Electrics. (*d*) Non-electrics.
- 3. *Electrical Apparatus.* (*a*) Machines. (*b*) Electrosopes. (*c*) Electrometers, &c.
- 4. *Electrical Light.* (*a*) Spark. (*b*) Brush. (*c*) Lightning. (*d*) Aurora Borealis.
- 5. *Situation of Charge.* (*a*) Surface. (*b*) Influence of form. (*c*) Points. (*d*) Lightning conductors.
- 6. *Induction.* (*a*) Polar arrangement. (*b*) Action of machine. (*c*) Electrophorus. (*d*) Condenser. (*e*) Leyden Jar. (*f*) Battery.

very little inconvenience. The best conductors of heat have the weakest attraction for it & part with it more readily than bad conductors. It is painful to touch metal at 120° . Water boils at 150° but as we have seen air heated to 250 or 300 may be borne without injury.

Different substances undergo different degrees of expansion. The same quantity of heat will expand air 5 times more than alcohol, 20 than mercury, 160 than platinum, 580 more than glass. In solids the expansion is comparatively small, in liquids it is more obvious, in gases very apparent. Commencing with Platinum which expands the least follows steel, iron, copper, brass, tin, lead, zinc. In constructing iron bridges &c. it is necessary to make allowance for the contraction & expansion of the metal. If a bar of iron & one of brass be riveted or soldered together it will warp in one direction or other by change of temperature. A compound plate of silver & platinum is remarkably susceptible of this change & is employed in instruments for the measurement of temperature, & also in clocks: the action of heat or cold on the pendulum is obviated by this contrivance, the plate to which the pendulum is attached is suspended between two compensating bars of this description. The warping of which according to the difference remedies the elongation & shortening of the pendulum.

The expansion of different liquids is liable to much variation & there is more expansion than alcohol, alcohol more than water & water than mercury. Generally speaking the rate of expansion increases with the temperature. Under the common atmospheric temperature water boils at 212° Alcohol 173° - Ether 96° - Mercury 660° , Sulphuric acid 590° - Lead melts at 594° - Hence sulphuric acid cannot be concentrated in leaden vessels. The only exception to the general rule of expansion & contraction is in water which unlike other fluids expands when cooled below a certain point. It begins to expand at 40° so that it will be of the same bulk at 32° as at 48° . This is of the utmost importance in nature

of water went on increasing in density till it froze
lakes & rivers instead of only being superficially
frozen w^d be solid masses of ice. The earth being
warmer in winter than the air, the heat is withdrawn
from the surface of f. water by the cold breeze,
& the water is reduced to 40° which is the point of
its greatest density. The cold continues to operate
on the ~~surface~~ of f. water but instead of render-
ing it heavier than the warmer water beneath
it expands it & makes it lighter so that a
stratum of ice cold water at 32° is found
floating on water at 40° .

Water is found to freeze & boil at nearly the
same temperature on all occasions. & from
this the thermometer has been graduated & is
used in England. in the centigrade a hundred
degrees is marked on the scale. The freezing point
being 0° . The boiling 100° . in Reaumur the
freez^g point is 0° . the boiling 80 . In Fahrenheit
the freez^g point is 32 & the boiling 112 & the
intermediate space is divided into 180° .
The degree of Fahrenheit equals $\frac{4}{9}$ of Reaumur.
& $\frac{9}{5}$ Centigrade.

Pyrometers are used to measure high degrees
of temperature. Wedgwood invented one which
consisted of pieces of clay fitted into a piece of
metal. Mr. Daniell has invented one by
which the expansion of a bar of platinum
enclosed in a case of black lead is capable
of measuring high degrees of temperature
with great nicety.

Aeriform bodies undergo much greater relative
changes of bulk than the other forms of matter
the force of cohesion being almost wanting the
expansive power of heat meets with less oppo-
sition. All pure aeriform bodies contract &
expand alike. The same kind of circulation
takes place in elastic fluids as in liquids
& thus an equilibrium of climate is main-
-tained?

Crystallization.

Attraction gives to bodies their peculiar form & figure. Every compound substance assumes when left alone to crystallize a form peculiar to itself. Electricity, light, & motion exert a great influence on the formation of crystals. Dr. Wollaston believed that all forms of crystals may be produced by the different modes of arranging a sphere. He invented a very delicate instrument for measuring the angles of crystals, the goniometer: it is so fine that it will measure the angle of the finest grain.

Different substances possess different crystalline forms. Calcareous spar crystallizes in rhombohedrons, fluor spar in cubes, quartz in 6 sided prisms &c. & these are never found under any other arrangement.

Electricity.

On rubbing a piece of glass & a piece of sealing wax, or lodestone or silk they both become excited, but in different degrees. From this Dufay supposed that there were two electricities, the vitreous and the resinous. Dr. Franklin supposed that there was only one kind of fluid, & that bodies which are resinously or negatively electrified on being excited lose a part of their electricity, as sealing wax - but that glass acquires during the same operation more than its usual quantity of electricity & becomes positively electrified.

Bodies similarly electrified repel each other, while those dissimilarly electrified

Attract each other. On rubbing a piece of glass with a silk handkerchief & putting it near a feather suspended by a piece of silk it will immediately attract it, but the moment the feather becomes saturated with electricity it is repelled: if however an excited stick of sealing wax is held near the feather when in this condition it is no longer repelled but by the glass but attracted. In these experiments the two substances rubbed together possess different electricities, one positive the other negative. All bodies may be divided into conductors & non conductors, which pass by insensible gradations into one another. The following is a table of different conducting substances.

- | | | |
|---------------------|----------------------|--------------|
| 1 All metals | 11 Rarefied air | |
| 2 Charcoal | 12 Vapour of alcohol | |
| 3 Acids | 13 Do of Ether | |
| 4 Saline Solutions | 14 Dry oxides | 21 Jet |
| 5 Animal fluids | 15 oils | 22 Wax |
| 6 Water | 16 Baked wood | 23 Sulphur |
| 7 Living vegetables | 17 Dry air | 24 Resin |
| 8 Minerals | 18 Hair | 25 Amber |
| 9 Flame | 19 Silk | 26 Shell lac |
| 10 Steam | 20 Glass | |

The 1st 13 may be called conductors the remaining non conductors. Fresh wood is a conductor, & its conducting power seems to depend upon the water it contains. Perfectly dry air is a non conductor but damp air conducts electricity with facility. Dufay conceived vitreous electricity to be peculiar to some bodies & resinous to others. Symmer on the contrary maintained that unexcited bodies contain both kinds of electricity in a state of combination, and as they then neutralize or counteract each others effects no electrical phenomena are apparent.

If a metallic rod be rubbed it will not exhibit the least sign of electricity, & this led to the division of bodies into electric and non-electrics. But the distinction does not exist, for if the rod is supported by a glass handle & then rubbed it will receive strong signs of electrical excitement. In the former experiments the electric fluid passes with such facility along the metal, it is in fact such a good conductor that it immediately passes into the hand & is dissipated. The electricity of a substance is influenced both by the state of its surface &

*The sources of electricity are friction, chemical action
contact of different metals. Proximity to an
electrified body -*

*All electrified bodies tend to produce in contiguous
substances an electric state opposite to their own -*

7. *Effects of Accumulation.* (a) Mechanical.
(b) Heating. (c) Shock.

8. *Excitation.* (a) Friction of non-conduc-
tors. (b) Change of physical state. (c)
Change of temperature. (d) Contact of
conductors.

B. CURRENT ELECTRICITY. (a) Experiments of
Galvani. (b) Galvanic circles.

1. *Voltaic pile.* (a) Courrone de Tasses.
(b) Batteries. (c) Large plates. (d) Small
plates.

2. *Theories.*

3. *Effects of Accumulation.* (a) Physiological.
(b) Heating. (c) Light. (d.) Tension.

VIII. MAGNETISM. (a) Attraction. (b) Re-
pulsion. (c) Polarity.

1. *Formation of Magnets.* (a) From the
loadstone. (b) By percussion. (c) By
position.

2. *Magnetism of the Earth.* (a) Compass
needle. (b) Dipping needle.

3. *Hypothesis of two Fluids.*

4. *Induction.*

A. ELECTRO - MAGNETISM. (a) Phenomena of
the closed Voltaic circuit. (b) Magnetic
helices. (c) Formation of permanent mag-
nets. (d) Formation of temporary magnets
by induction.

1. *Magnetic Rotation.* (a) Pole round the

wire. (b) Wire round a pole. (c) Barlow's wheel. (d) Magnet upon its axis.

2. *Theory of Vertiginous Currents.*

3. *Electro-Magnetic Multipliers.*

B. THERMO-ELECTRICITY. (a) Deflection of the needle. (b) Rotation.

C. MAGNETO-ELECTRICITY.

1. *Induction of Electricity from closed Voltaic Circuit.*

2. *Induction of Electricity from a Loadstone or Magnet.* (a) Deflection of the needle. (b) Electric spark.

3. *Induction of Electricity from the Earth's Magnetism.*

4. *Magnetic and Electric Motion.* (a) A current of electricity causes a magnetic pole to rotate. (b) The rotation of a pole causes a current of electricity. (c) Rotation of metallic discs.

IX. RADIANT MATTER. (A.) Light. (B.) Radiant heat.

A. LIGHT. (a) Propagation. (b) Photometry.

1. *Theories.* (a) Emission. (b) Undulation.

2. *Reflexion.* (a) Plane surfaces. (b) Curved surfaces.

3. *Radiation.*

4. *Refraction.* (a) Prism. (b) Curved Surfaces.

the body with which it is rubbed. Smooth glass is rendered positive by friction, while rough glass is becomes negative. And smooth glass becomes positive with cats skin. The electricity which is so freely evolved by a good machine is derived from the earth, for if the apparatus is insulated, the evolution immediately ceases, & is instantly restored when the communication with the earth is again established. - The electric fluid resides in or near the surface of bodies, but is distributed in different ways: A sphere is the only shape in which there is an equality of distribution: Coulomb has invented an instrument by which the intensity of electricity can be measured on the surface of a body: in a cylinder the intensity is much greater at the poles than in the centre: if 2 spheres are brought together the intensity is likewise at the poles, while at their junction it is null.

Galvanism Discovered by Galvani in 1790

The excitation of electricity by the contact of metals gives rise to what has been termed galvanism, Voltaic or current electricity. The original discoverer of a successful mode of accumulating electricity generated by the metals was Volta, who constructed a pile consisting of a number of plates of two different metals arranged in regular order of succession with a piece of moistened flannel or pasteboard alternating. Various modifications of this have been used, & for convenience the galvanic trough is now generally employed. In these arrangements there is a positive (Zinc) and a negative (Copper) ^{plate} & a central point which exhibits no electricity. Electric intensity varies according to the number of the plates employed, quantity according to the size of the plates. The wire connected with the copper end is the positive pole, the one with the zinc the negative. Volta supposed that the electricity was set in motion, and the supply kept up, solely by contact

a communication between the two metals. He regarded the liquid interposed merely as a conductor of the electricity. Dr. Wollaston assigned chemical action as the cause by which it is excited; the oxidation of the zinc he thought was the primary cause of the development of electricity. Sir H. Davy proposed a theory intermediate between these two. He thought that the action commenced by contact of the metals, & was kept up by the chemical phenomena.

The effects of galvanism may be classed under 3 heads, 1st Electrical effects. 2nd The chemical agency. 3rd its action on the magnet.

- 1 The agent or power excited by the voltaic apparatus appears to be identical with that called into activity by the electrical machine. For not only may all the common electrical experiments be performed by galvanism, but the chemical effects of the galv: battery may be produced by electricity.
- 2 When two gold or platinum wires connected with a battery are plunged by their free extremities into a cup of water, hydrogen gas is discharged at the negative wire & oxygen at the positive. The galvanic action not only separates the elements of bodies, but subverts the operation of affinity so entirely, as to enable an acid to pass through an alkaline solution, or an alkali through water containing a free acid, without combination taking place.

Now in all instances of common electrical ^{attraction} ~~operation~~ the bodies attract one another in consequence of being in opposite states of excitement, and in like manner the tendency

of acids towards the zinc, and of alkalis towards the copper end of the voltaic apparatus, can be explained consistently with our present knowledge, only on the supposition that the former are negatively, and the latter positively electric, at the time of being separated from one another. Sir H. Davy observed that a dry alkali is excited positively by contact with a metal, & that dry acids after having touched a metal are negative. He further found that acids & alkalis in their dry state excite each other, the former after contact becoming negative & the latter positive. The two particles are thus rendered oppositely electric & if not prevented by cohesion to particles of their own kind, or other causes, thus remain permanently attached to each other by the force of electrical attraction & thus give rise to a new compound. When Chemists therefore term chemical attraction an electrical force arising from particles of a different kind attracting each other, in consequence of being in opposite states of electrical excitement. The opposing compounds to a galvanic battery & observing the pole at which the elements appear. Those that collect round the positive pole are said to have a negative electric energy, & vice versa. Oxygen, Chlorine, Iodine, Bromine, & Fluorine are regarded as negative electrics, the others compose the list of positive electrics.

The power of lightning in destroying & reversing the poles of a magnet & in communicating magnetic properties to iron, was noticed at an early period, but Professor Ørsted in 1819 first discovered that an electric current caused a magnetic needle placed near it to deviate from its natural position & assume a new one. It not only determines the position of the needle, but renders steel permanently magnetic. Soft iron does not retain magnetism, but while under the influence of the current its magnetic properties are very surprising.

Light is similar to Caloric in many of its properties. They are both emitted in the form of rays, traverse the air in straight lines, and are subject to the same laws of reflection. The intensity of each diminishes as the square of the distance from their source.

There are 2 kinds of light, natural & artificial. The former proceeding from the sun & stars, the latter from bodies which are strongly heated. Solar light is capable of producing powerful chemical changes, as for instance its power of darkening the white chloride of silver.

5. *Decomposition.* (a) Solar spectrum. (b) Artificial spectra. (c) Homogeneous light. (d) Thin plates and lines.
6. *Double Refraction.*
7. *Polarization.* (a) By refraction. (b) By reflexion. (d) Depolarization.

B. RADIANT HEAT.

1. *Solar.* (a) Reflexion. (b) Refraction. (c.) Absorption. (d) Polarization.
2. *Terrestrial.* (a) Reflexion. (b) Refraction. (c) Apparent reflexion of cold. (d) Influence of surface and colour. (e) Laws of cooling by radiation. (f.) Phenomena of dew.

X. CHEMICAL AFFINITY.

1. *Mixture.* (a) Diffusion of gases. (b) Endosmose. (c) Mixture of liquids. (d) Separation of mixtures. (Evaporation, Distillation, &c.)
2. *Solution.* (a) Of solids. (b) Of gases. (c) Saturation. (d) Separation.
3. *Composition.* (a) Definite proportions. (b.) Multiple proportions. (c) Change of properties. (d) Neutralization. (e) Single elective affinity. (f) Double elective affinity. (g) Antagonist forces. (h) Influence of quantity. (i) Influence of heat. (k) Decomposition.

XI. HEAT OF COMPOSITION.

1. *Specific Heat.* (a) Mixtures. (b) Heating

and cooling. (c) Condensation. (d) Rarification.

2. *Latent Heat.* (a) Congelation. (b) Boiling. (c) Steam engines. (d) Evaporation. (e) Hygrometry. (f) Oscillation of the barometer.

XII. CHEMICAL RELATIONS OF ELECTRICITY.

1. *Voltaic Electricity.* (a) Chemical action in the pile. (b) Affinity counteracted. (c) Affinity promoted. (d) Voltaic protection.
2. *Common Electricity.* (a) Decomposition.
3. *Theory.*
4. *Electro-Negative and Electro-Positive Elements.*

XIII. CHEMICAL RELATIONS OF MAGNETISM. (a) Alloys. (b) Crystallization.

XIV. CHEMICAL RELATIONS OF LIGHT.

1. *Composition.* (a) Decomposition. (b) Crystallization. (c) Vegetation. (d) Bleaching.
2. *Phosphorescence.*

Chemical Affinity -

Chem: attract: acts on the particles of dissimilar substances at insensible distances, & is distinguished from attract: of cohesion by the latter acting on homogeneous or similar particles. Chemical mixture can only take place between fluids in the same physical state. Between some liquids there is no attraction whatever: if ether & water are mixed no permanent combination can be produced, & this does not depend on their different specific gravities, for we find Sulphuric acid which is twice as heavy as water, readily combines with it in any proportion. All uniform bodies have the property of mixing notwithstanding their difference of gravity: & this appears to arise from their want of cohesive attraction. If a small jar containing atmospheric air be placed under a larger one containing hydrogen, the former being covered with a piece of caoutchouc, the hydrogen will ultimately pass into the small one through it. The diffusion is effected by an interchange in position. The same takes place with regard to liquids: if a vessel covered with bladder, or tied in a vessel of water, diffusion of the two fluids will take place. This was termed by Mr. Dutrochet Endosmosis. Chemical mixture causes condensation in volume - If 2 bulbs joined together are filled, the one with water, the other with Sulphuric acid & then agitated, they will be found to diminish in bulk & not fill the bulbs.

Solution. Different bodies have different attractive powers, & accordingly if several are brought together those which have the strongest mutual attract: will enter first into union: resin is easily dissolved in spirit of wine, but if some of this solution is dropped into water, the spirit having a greater affinity for the water than for the resin sets the latter free which is precipitated: this is termed elective attraction. Unlike mixture there is a limit to solution, it is limited by the power of cohesion. Thus water will take up half its weight of sulphate of ammonia but a very small quantity not more than 500 part of sulphate of lime. The union of Carbonic acid gas with water is an instance

of solution of gaseous bodies, & its solution is only limited by its elastic power; if this is overcome by pressure it may be made to take up a very large proportion. Heat in solids considerably increases the power of solution, the attraction of cohesion is lessened & elasticity has a greater ascendency. Solution of some solids produces a diminution of temperature: in solution of nitrate of potash the temperature is reduced 17 degrees & in the case of nitrate of ammonium from 50° to 4° .

Composition is the result of the highest degree of chemical attract. but the union of bodies takes place only in definite proportions produced under whatever circumstances. If carbonic acid gas is passed through lime water chalk is formed, which is a definite compound of carb: acid & lime & whether we examine it in this state or in the crystal, or in the animal product, egg shell, the combining proportion will be exactly the same.

The evolution of heat & light are common consequences of chemical action, & also changes in the physical properties of bodies: eg. 2 gaseous bodies may produce a solid as ammonia & muriatic acid in the form of gas produce murex of ammonia: or 2 fluids may produce a solid, as a solution of muriate of lime & one of carbonate of potassa, or 2 solids may produce a fluid as by rubbing sulphate of soda & nitrate of ammonium together. If to a combination of 2 substances a 3rd be added a new compound will be produced.

If to a solution of copper in sulphuric acid a piece of iron is added the copper is precipitated & the acid acts upon the iron. If to a solution of baryta in nitric acid a sufficient quantity of sulphuric acid be added it will combine with the baryta forming an insoluble precipitate, while the nitric acid will be set free. This is an instance of simple decomposition. If however a solution of sulphate of soda be added to one of nitrate of baryta a double decomposition will take place & sulphate of baryta & nitrate of soda will be the result.

Part II.

THE STUDY OF CHEMISTRY IN THE
HIGH SCHOOL.

1. NON-METALLIC ELEMENTARY PRINCIPLES.

- 1. Hydrogen, Oxygen, Hydrogen Peroxide, (1)
Nitrogen, Chlorine.
- 2. Carbon, Sulfur, Phosphorus, (2)
Silicon, Boron, Magnesium, Aluminum.
- 3. Fluorine, Iodine, (3)
Bromine.

2. THE METALS.

3. GENERAL NON-METALLIC CHEMISTRY.

4. THE STUDY OF CHEMISTRY IN THE
LABORATORY.

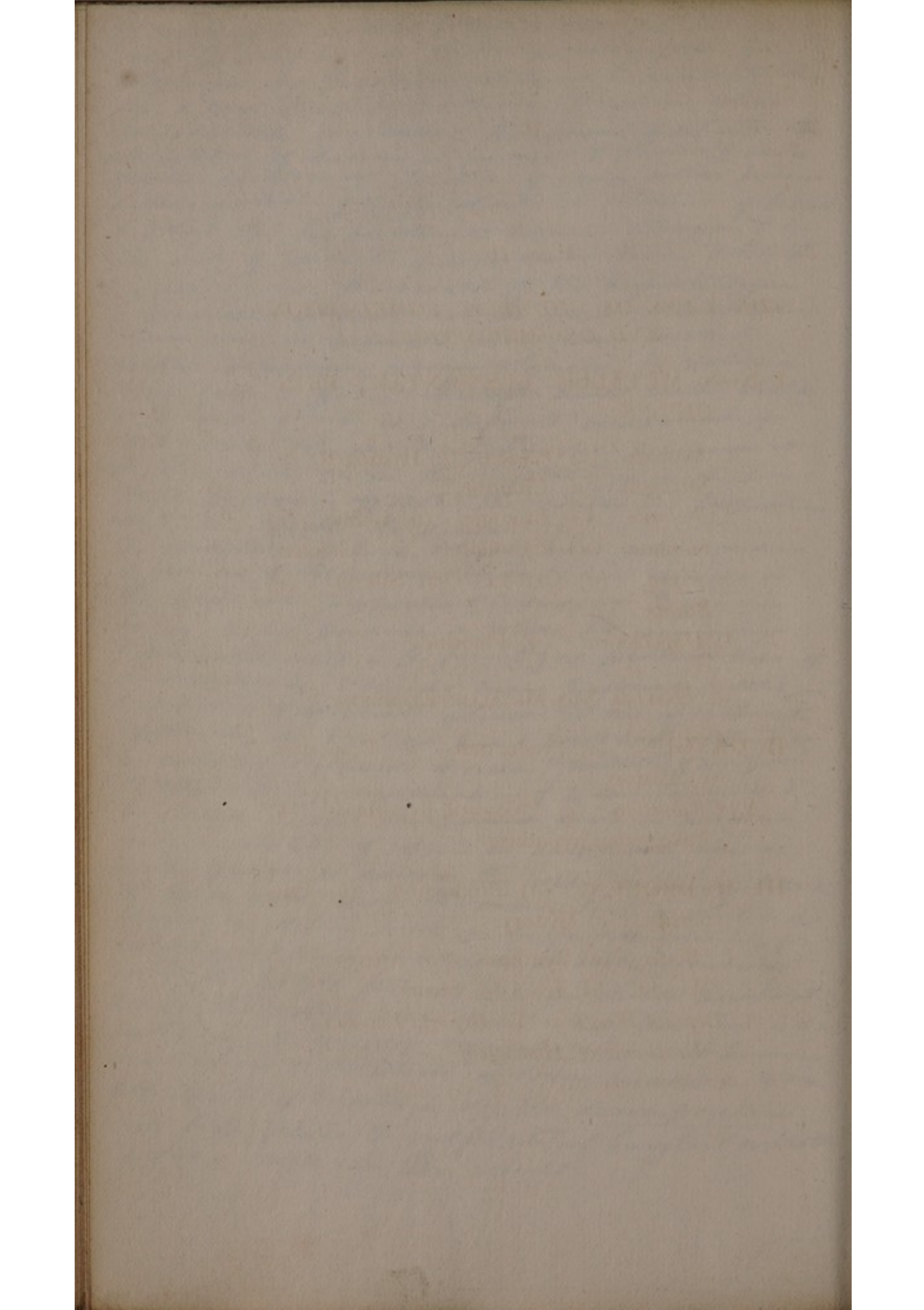
- 5. Nitrogen, Oxygen, Hydrogen Peroxide, (4)
Carbon Dioxide.

6. HYDROGEN, OXYGEN, HYDROGEN PEROXIDE, (5)
NITROGEN, CHLORINE.

- 7. Hydrogen, Oxygen, Hydrogen Peroxide, (6)
Nitrogen, Chlorine.

- 8. Hydrogen, Oxygen, Hydrogen Peroxide, (7)
Nitrogen, Chlorine.

- 9. Hydrogen, Oxygen, Hydrogen Peroxide, (8)
Nitrogen, Chlorine.



PART II.

THE LAWS OF CHEMICAL COMBINATION
AND DECOMPOSITION.

I. NON-METALLIC ELEMENTARY PRINCIPLES.

1. *Gaseous.* (a) Oxygen. (b) Hydrogen. (c) Nitrogen. (d) Chlorine.
2. *Volatile.* (a) Bromine. (b) Iodine. (c) Sulphur. (d) Phosphorus. (e) Selenium.
3. *Fixed.* (a) Carbon. (b) Silicon. (c) Boron.
4. *Hypothetical.* (a) Fluorine.

1. GASEOUS NON-METALLIC ELEMENTS.

II. OXYGEN. (a) Production. (b) Properties.
(c) History.

- A. *Combustion.* (a) Phlogistic hypothesis. (b) Lavoisarian hypothesis.

III. HYDROGEN. (a) Production. (b) Properties. (c) History.

1. *Water.* (a) Synthesis. (b) Analysis. (c) Weight. (d) Ice. (e) Steam.

A. *Definite Weights.* B. *Definite Volumes.*

2. *Deutoxide of Hydrogen.*

A. *Nomenclature.*

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IV. NITROGEN. (a) Production. (b) Properties. (c) History.

A. *Atmospheric Air.* (a) Eudiometry.

B. *Nomenclature.*

1. *Compounds of Nitrogen with Oxygen.* (a) Protoxide of nitrogen. (b) Deutoxide of nitrogen. (c) Hypo-nitrous acid. (d) Nitrous acid. (e) Nitric acid.
2. *Compounds of Nitrogen and Hydrogen.* (a) Ammonia. (b) Hypothesis of Ammonium.

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V. CHLORINE. (a) Production. (b) Properties. (c) History.

1. *Compounds of Chlorine and Oxygen.* (a) Protoxide of Chlorine. (b) Peroxide of Chlorine. (c) Chloric acid. (d) Perchloric acid.
2. *Compounds of Chlorine and Hydrogen.* (a) Muriatic acid.
3. *Compounds of Chlorine and Nitrogen.* (a) Chloride of nitrogen.

VI. PROXIMATE PRINCIPLES.

1. *Acids.*
2. *Alkalies.*
3. *Salts.* (a) Water of crystallization. (b) Hydrates.

VII. SCALE OF EQUIVALENTS. (a) Hydrogen scale. (b) Oxygen scale.

Oxygen - Discovered by Dr. Priestley in 1774
 & called by him dephlogisticated air & by Scheele
 Emphyreal air - The most convenient way of
 obtaining it pure is by exposing chlorate of potash
 to heat & fusing it. 100 grs. will give off from
 110 to 115 cubic inches of pure gas. Black
 oxide of manganese yields it readily when
 exposed to red heat when quantity is required.
 It is constantly formed in nature by vegetation.
 Oxygen is colourless, has neither smell or taste.
 It is a most perfect negative electric, always
 appearing at the positive pole when any
 compound containing it is exposed to the action
 of galvanism. It may be breathed with
 impunity for some time & is necessary to
 respiration, but is ultimately injurious to
 animal life in a state of purity. It is rather
 heavier than atmosphere air - $\frac{1}{16}$ gr. according
 to Thomson is 1.111. 100 cubic inches of common
 air weighs $30\frac{1}{2}$ grs. The same quantity of gas
 weighs $34\frac{1}{2}$ grs. It refracts light very feebly. It is very
 sparingly soluble in water. It has a very pow-
 erful attraction for most simple substances
 and may be made to combine with all of them.
 Combustion is supported with far greater brilliancy
 in oxygen than in common air. Oxidation gives
 rise to these compounds, acids, alkalis & oxides.
 If phosphorus is burned in oxygen an acid is formed,
 an alkali if potassium, and an oxide if iron -
 In the combustion of a body oxygen gas invariably
 disappears and a new compound consisting of
 oxygen & the combustible is generated.

Hydrogen, inflammable air, or phlogiston is most readily obtained by pouring dilute sulphuric acid on iron or zinc filings in a glass retort. It is a colourless gas, & when perfectly pure has neither odour or taste. It is a powerful refractor of light. It is the lightest of all bodies, 100 cubic inches weighs about $2\frac{1}{10}$ grs. It is speedily fatal to animal life, but appears to be so from deprivation of oxygen rather than from any noxious quality of the hydrogen, since air & atmosphere composed of due quantities of each may be respired without inconvenience. It is highly inflammable but will not support combustion. It burns when it is in contact with the air. When mixed with oxygen or common air violent explosion takes place on applying a taper. The proportion for this purpose is 2 measures of hydrogen to 1 of oxygen. Sudden & violent compression will cause explosion. Spongy platinum explodes this mixture as soon as flame. A large quantity of caloric is evolved during the combustion of hydrogen gas, & its combustion in oxygen produces the most intense heat that is known. Water is the sole product of the combustion of hydrogen. Oxygen & H_2 unite in the proportion of 1 measure of the former to 2 of the latter to form it. When there is an excess of either it is left behind after the explosion. It is obtained by decomposing water by passing it over iron at a red heat, the oxygen unites with the metal while the hydrogen is set free.

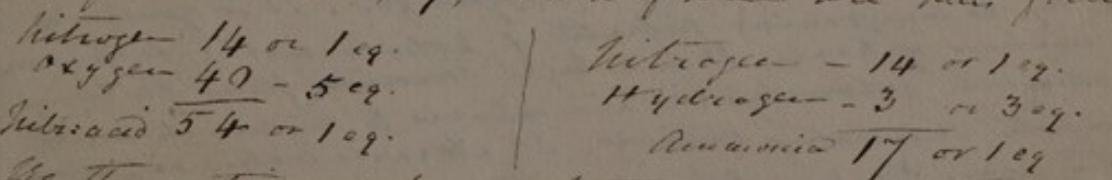
Nitrogen or Azote - First discovered by D. Rutherford in 1792. It is of the electric positive class, & consti-
-tutes $\frac{4}{5}$ of atmospheric air. It is easily obtained by the combustion of phosphorus in common air. The strong affinity of phosph: for oxygen causes it to burn till all that gas is consumed, & the residue is nitrogen. It may also be obtain-
-ed by exposing a mixture of fresh muscle & nitric acid to a moderate temperature.

It is a permanent colourless, inodorous gas, elastic, compressible, but cannot be condensed into a fluid, cannot support combustion, and destructive to animal life, from privation of oxygen. 100 cub: in. weigh 30.15 grs. while atmos-
-pheric air is 31.017 grs. The pressure of the atmosphere is about 15 pounds on every sq. inch & is capable of supporting a column of water 34 ft. high & one of mercury 30 inches. i.e. a column of mercury 1 inc: square & 30 in. long has the same weight (nearly 15 lbs.) as the same sized column of water 34 ft. long, & one of air reaching from the level of the sea to the limit of the atmosphere. It is highly compressible & elastic. The atmosphere is supposed to extend about 45 miles from the sur-
-face. It is composed of 21 parts of oxygen & 79 of nitrogen combined with a small proportion of carbonic acid gas.

There are 5 Compounds of Nitrogen & Oxygen - viz.

	Nitrogen	Oxygen	equivalent -
1 <u>Protoxide of Nitrogen</u> (Turner)	14	8	= 22
2 <u>Deutoxide of Nitrogen</u> (Turner)	14	16	= 30
3 <u>Hypoxitrous Acid</u>	14	24	= 38
4 <u>Nitrous Acid</u>	14	32	= 46
5 <u>Nitric Acid</u>	14	40	= 54

1st Protoxide of Nitrogen - Is most readily obtained by fusing nitrate of ammonia in a retort. In this process water & protoxide of nitrogen are formed. Nitrate of ammonia is formed of one equivalent of nitric acid, 54, & 1 of ammonia, 17, & each of these are thus formed,



By the action of heat these arrange themselves in a new order: Hydrogen takes as much oxygen as is sufficient to form water, & the residual oxygen combines the nitrogen of both the acid & ammonia into protoxide of nitrogen. It is soluble to a certain extent in water, but less so in warm than cold.

It is colourless, heavier than atmospheric air, of a sweet taste faintly agreeable smell & supports combustion like oxygen with an equal bulk of Hydrogen it forms an explosive mixture. The combustible matter in these cases unites with the oxygen & the nitrogen is set free. Animals confined in it die speedily, though it may be breathed for a short time with impunity & produces peculiar excitement in the system, laughter &c. Subjected to the pressure of 50 atmospheres, Mr. Faraday obtained it in a liquid state.

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2. Protoxide of Nitrogen is best obtained by the action of nitric acid on metallic copper. Effervescence takes place & the gas may be collected over water or mercury. One portion of nitric acid suffers decomposition; part of its oxygen oxidizes the copper, while another part is retained by the nitrogen of the nitric acid forming deutoxide of nitrogen. The oxide of copper unites to some undecomposed nitric acid forms the blue nitrate of copper. It is a colourless gas, not so soluble as the protoxide; wholly irrespirable. It has no acid properties unless combined with oxygen when it gives off dense suffocating acid vapours of a red colour. It extinguishes a lighted taper but if phosphorus in a state of combustion be put into it, it burns with increased splendour, phosphoric acid being the product. It is a little heavier than atmospheric air. By exposure to zinc or iron it is decomposed, 1 vol. of oxygen is absorbed, leaving a protoxide. It is absorbed in great quantity by green vitriol, protosulphate of iron.

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3. Hyponitrous acid: it may be produced by an addition of oxygen to the deutoxide. It cannot be obtained in a pure state

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4. Nitrous acid: This is the result of the red vapour formed by mixing oxygen with the deutoxide: heat & condensation takes place, & by the application of ice & salt to the vessel it is produced in a liquid form. Increase of temperature produces increase of colour, making it nearly black. The liquid acid may be at once obtained by exposing Nitrate of lead to a low red heat. The liquid anhydrous acid has a powerfully corrosive acid taste, pungent odour, & of a yellowish orange colour. On mixing it with a large quantity of water it is instantly resolved into nitric acid, & deutoxide of nitrogen. The former unites with the water, the latter escapes in the form of gas.

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5. Nitric Acid, may be produced by passing deutoxide of nitrogen slowly over water into oxygen gas. It is generally produced by decomposing nitrate of potash with sulphuric acid by means of heat. It is a highly corrosive fluid & when pure almost colourless: when exposed to the air it emits dense white suffocating vapours. It attracts watery vapour from the air, & a rise of temperature is occasioned by its mixture with water. It oxidizes metals rapidly. Nitrogen combining with Hydrogen gives rise to Ammoniacal gas. It is a colourless gas of strong

2. VOLATILE NON-METALLIC ELEMENTS.

78.26 / Borzelli.

VIII. BROMINE. (a) Production. (b) Properties. *Electro Negative*
(c) History.

1. *Compounds of Bromine and Oxygen.* (a)
Bromic acid.
2. *Compounds of Bromine and Hydrogen.* (a)
Hydro-bromic acid.
3. *Other Binary Compounds of Bromine.*

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IX. IODINE. (a) Production. (b) Properties. *Electro Negative*
(c) History.

1. *Compounds of Iodine and Oxygen.* (a)
Iodic acid.
2. *Compounds of Iodine and Hydrogen.* (a)
Hydriodic acid.
3. *Other Binary Compounds of Iodine.*

X. SULPHUR. (a) Production. (b) Properties. *Electro positive*
(c) History.

1. *Compounds of Sulphur and Oxygen.* (a)
Sulphurous acid. (b) Sulphuric acid. (c)
Hypo-sulphurous acid. (d) Hypo-sulphuric acid.
2. *Compounds of Sulphur and Hydrogen.* (a)
Sulphuretted hydrogen. (b) Bi-sulphuretted hydrogen.
3. *Other Binary compounds of Sulphur.*

Electro-positives: XI. PHOSPHORUS. (a) Production. (b) Properties. (c) History.

1. *Compounds of Phosphorus and Oxygen.* (a) Phosphorous acid. (b) Phosphoric acid. (c) Hypo-phosphorous acid.
2. *Compounds of Phosphorus and Hydrogen.* (a) Per-phosphuretted hydrogen. (b) Proto-phosphuretted hydrogen.
3. *Other Binary Compounds of Phosphorus.*

Electro-positives: XII. SELENIUM. (a) Production. (b) Properties. (c) History.

1. *Compounds of Selenium and Oxygen.* (a) Selenious acid. (b) Selenic acid.
2. *Compounds of Selenium and Hydrogen.* (a) Seleniuretted hydrogen.
3. *Other Binary Compounds of Selenium.*

3. FIXED NON-METALLIC ELEMENTS.

XIII. CARBON. (a) Diamond. (b) Plumbago. (c) Charcoal. (d) Production. (e) Properties. (f) History.

1. *Compounds of Carbon and Oxygen.* (a) Carbonic oxide. (b) Carbonic acid. (c) Oxalic acid.

A. DETECTION OF POISONS.

2. *Compounds of Carbon and Hydrogen.* (a)

penetrant odour, & when pure quite irresistible. It ex-
tinguishes burning bodies. A mixture of ammoniacal gas
& oxygen detonates ~~at~~ by the electric spark water being formed
& nitrogen set free. It is most easily obtained by applying
gentle heat to the concentrated solution of ammonia. The
gas at the temperature of 50° & at the pressure of 6 atmos-
pheres becomes liquid. Ammonia has all the properties
of an alkali. It is formed of 3 equivalents of Hydrogen & 1 of
Nitrogen - 17. Vits. sp. gr. is 0.5902. It has a powerful
affinity for water, & therefore must be collected over mercury
according to Dr. Thompson water takes up 780 times its
bulk. The concentrated solution is made by passing
a current of the gas through distilled water as long
as it continues to be absorbed. It may also be
obtained from any salt of ammonia by the action of
any alkali upon it, as muriate of ammonia &
lime. The presence of ammonia gas may always
be detected by its forming dense white fumes,
muriate of ammonia, when a glass rod moistened
with muriatic acid is brought near it.

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Chlorine - Discovered by Scheele in 1775 & called dephlog-
sicated marine acid, & by the French pyromuriatic
acid, & by Sir H. Davy, Chlorine. It is obtained by taking
3 pts. of common salt & 1 of black ^{per-}oxide of manganese
& pouring over this sulphuric acid diluted with an
equal weight of water. It may also be obtained by
mixing strong muriatic acid with half its weight
of peroxide of manganese. Muriatic acid, composed of
1 eq. of chlorine & 1 of hydrogen, & perox: of manganese
of 1 eq. of manganese, & 2 eq. of oxygen, gives 1 eq. of ox:
to the hyd: of the acid, & generates 1 eq. of water & 1 eq. of
chlorine disengaged; while the protox: of manganese
unites with 1 eq. of undecomposed muriatic acid & forms
1 eq. of muriate of the protox: of manganese. The affinities
which determine these changes are the attract: of oxygen
for Hydrogen & protoxide of mang: for muriatic acid.
In the 1st mode of preparing it muriatic acid is
disengaged by the action of sulph: acid on the salt
which reacts as in the latter on the manganese, but
the protox: of mang: unites with sulph: acid instead
of muriatic & forms sulphate of manganese & soda.
Chlorine is an electro negative substance, of a yellow-
green colour, astringent taste, & suffocating smell.
Water takes up twice its volume of the gas & has all
its properties. 100 cub. in weighs $\frac{7}{10}$ grs. when strongly
& suddenly compressed it unites both heat & light &
under the pressure of about 4 atmospheres it becomes
liquid. It is not acted upon by heat, electricity or
galvanism. Light does not act on dry chlorine but
if water is present it is decomposed the chlorine unites
with the hydrogen to form muri: acid & oxygen is set free.

a lighter lamp burns for a short time in it & meets a large quantity of smoke. Phosphorus takes fire in it & burns spontaneously - Several of the metals in the state of powder or fine leaves, as tin, copper, zinc, antimony &c. are suddenly inflamed in it. It has the property of destroying vegetable colours, this depends on the presence of water. Dry chlorine has not this effect. It is a powerful antiseptic & fumigator, it destroys the volatile principle of putrefying animal matter. It possesses no acid properties - chlorine combines with oxygen, hydrogen & nitrogen, but has a very powerful attraction for hydrogen. The compounds of chlorine which are not acids are termed Chlorides or Chlorurets.

Compounds of Chlorine by volume -

	Chlorine	Oxygen	Hydrogen	Nitrogen
1 Protoxide of Chlorine	36	8	2	1
2 Peroxide of do	36	32	2	4
3 Chloric Acid	36	40	2	5
4 Perchloric Acid	36	56	2	7

These are never met with in nature in a state of combination, & have a very feeble affinity for each other.

1. Protoxide of Chlorine, discovered by Davy in 1811. It is formed by the action of muriatic acid on chlorate of potash. It is of a yellowish green colour & smells like burnt sugar. It readily combines with water & has bleaching properties. It is explosive in a high degree even by the heat of the hand or by pouring from one vessel to another mixed with hydrogen & exploded by flame or the electric spark water & muriatic acid are formed.

2. Peroxide of Chlorine, discovered 1816 by Davy. It is formed by the action of sulphuric acid on chlorate of potash. A dense gas is formed of a deeper colour than chlorine & so heavy that it may be poured from one vessel to another. It has no sensible action on mercury & may be collected over it. Its smell is not so noxious as chlorine. It explodes violently at 212°. & phosphorus when introduced into it takes fire & occasions explosion.

3. Chloric Acid. When to a dilute solution of chlorate of baryta a quantity of weak sulphuric acid is added the insoluble sulphate of baryta subsides & pure chloric acid remains in the liquid. It has acid properties, pungent smell, & forms neutral salts called chlorates, with alkaline bases.

4. Perchloric acid, obtained from perchlorate of potash & diluted sulphuric acid on application of heat. It is the most permanent of the compounds of Chlorine.

Compounds of Chlorine & Hydrogen - Muriatic Acid Gas.

It was discovered in 1772 by Priestley & was called hydro-chloric acid gas. It may be obtained either by heating pure muriatic acid, or by pouring sulphuric acid on common sea salt & collecting the gas over mercury. In the latter process, the salt being composed of chlorine & sodium, by the action of sulphuric acid on it, 1 equiv. of water is resolved into its elements; its hydrogen unites with chlorine forming muriatic acid which escapes in the form of gas, while soda is formed by the combination of its oxygen with sodium, which combines with the sulph. acid forming sulphate of soda: the attractions are chlorine for hydrogen, sodium for oxygen, & sulph. acid for soda. By passing an electric spark through equal measures of hydrogen & chlorine mur. acid is formed. The sp. gr. of mur. acid gas is 1.2697. It is composed of 129. of each = 34. It is a colourless gas, of pungent odour & acid taste: under a pressure of 40 atmospheres it is liquid. It is quite irrespirable. It will not support combustion. Water at 40°. absorbs, 480 times its volume of the gas. It is not chemically changed by mere heat, but is readily decomposed by galvanism, hydrogen appearing at the negative, & chlorine at the positive pole. If a mix. of oxyg. & mur. acid gas is electrified the ox. unites with the hydrogen to form water, & chlorine is set free. It has a powerful attract. for water, & whenever the gas escapes into the air a dense white cloud is formed by its combination with the watery vapour.

Compound of Chlorine & Nitrogen. Chloride of Nitrogen.
Chlorine & Nitrogen have a very slight affinity for
each other. Chloride of Nitrogen is obtained by passing
chlorine through a solution of ammonia: the
ammonia is decomposed into hydrogen units,
which combine with chlorine forming muriatic acid, while the Nitrogen
& chlorine combine. It is one of the most explosive
compounds yet known, its sp. gr. 1.653. it does
not become solid at intense cold. It explodes on
a low temperature & more contact with substances
of a combustible nature at common tempera-
tures, causes detonation: oils & fatty substances
produce this effect. By the analysis of Sir H. Davy
it is composed of 42g. of chlorine & 1 of Nitrogen.

78

Bromine. This is the last of the Elementary sub-
stances which have been discovered. It is obtained
in small quantities from sea water: it has
been detected in the waters of the Mediterranean,
Baltic, North Sea, Firth of Forth, Dead sea, & in salt
springs in Germany. In its chemical relations, it
bears a close analogy to Chlorine & Iodine.
It is usually obtained by passing chlorine through
litters, the residue of the evaporation of sea water; the
chlorine unites with hydrogen & bromine is set
free. By adding sulphuric ether to the solution &
agitating it, the ether dissolves the whole of the bromine.
At common temperatures bromine is a liquid of a
red colour & emits copious red fumes: its odour,
from which it derives its name, is very disagreeable,
& its taste powerful. Its sp. gr. is 3. It is very volatile
& boils readily (110°). It is electr. negative. It readily dissolves
in water, alcohol & ether. It bleaches rapidly, like chlorine.
It is highly destructive to animal life, one drop placed on
the back of a bird proves fatal. In its combinations &
its action on metals it is very analogous to chlorine.
Antimony & tin take fire by contact with it, & its union
with potassium is so vehement as frequently to burst the
vessel in which the experiment is performed.

- Sub-carburetted hydrogen. (b) Carburetted hydrogen.
- A. FLAME. (a) Artificial illumination. (b) Drummond's light. (c) Safety-lamp. (d) Blow-pipes.
- B. GAS LIGHTING. (a) Coal gas. (b) Oil and rosin gas. (c) Portable gas.
- C. *Other forms of Hydro-carbon.* (a) Napthaline. (b) Sulpho-napthalic acid, &c.
3. *Compounds of Carbon with Chlorine.* (a) Per-chloride of Carbon. (b) Chloride of Carbon. (c) Sub-chloride of Carbon. (d) Chloro-carbonic acid.
4. *Compounds of Carbon and Sulphur.* (a) Sulphuret of carbon. (b) Xanthogen.
- A. COMPOUNDS OF XANTHOGEN. (a) Xanthic acid.
5. *Compounds of Carbon with Nitrogen.* (a) Cyanogen.
- A. COMPOUNDS OF CYANOGEN WITH HYDROGEN. (a) Hydro-cyanic acid. (b) Ferro-cyanic acid.
- B. *Compounds of Cyanogen and Oxygen.* (a) Cyanous acid. (b) Cyanic acid. (c) Fulminic acid.
- C. *Compounds of Cyanogen and Chlorine.* (a) Chloro-cyanic acid. (b) Per-chloride of cyanogen.
- D. *Compounds of Cyanogen with Sulphur.* (a) Sulpho-cyanic acid.

XIV. SILICON. (a) Preparation. (b) Properties. (c) History.

1. *Compounds of Silicon.* (a) Silica. (b) Chloride of Silicon. (c) Sulphuret of silicon. (d) With metals.

XV. BORON. (a) Preparation. (b) Properties. (c) History.

1. *Compounds of Boron.* (a) Boracic acid. (b) Chloride of Boron.

4. HYPOTHETICAL ELEMENT.

XVI. FLUORINE.

1. *Compounds of Fluorine.* (a) Hydro-fluoric acid. (b) Fluo-silicic acid. (c) Fluo-boracic acid.

Hydro-bromic acid - No chemical action takes place between Hydrogen & the vapour of bromine at common temperatures, but on introducing a piece of red hot iron into the mixture combination ensues. The combination is readily affected by the action of bromine on some of the gaseous compounds of hydrogen, & hydro-bromic acid is generated. It is colourless, of an acid taste, pungent odour, & powerfully irritating when respired. Chlorine decomposes it immediately & muriatic acid is formed & bromine deposited. Water absorbs it readily. It is formed of 1 volume of bromine & 1 of hydrogen.

Bromic Acid - is formed by the action of bromine on pure potash, when by decomposition of water, & union of its elements with separate portions of bromine bromic & hydrobromic acids are generated. Bromic acid has scarcely any smell, but is very acid, though not corrosive - it consists of 1 eq. of bromine & 5 of oxygen
 $+ 40 =$

Bromine (Chloride of) Formed by transmitting chlorine through bromine. A volatile fluid of a reddish yellow colour is formed, soluble in water, & decomposed by the alkalis into muriatic & bromic acids.

Bromide of Iodine

Bromide of Sulphur By pouring bromine on sublimed sulphur an oily fluid of a reddish tint is formed. If boiling water is poured on it slight detonation ensues & hydro-bromic, & sulphuric acids, & sulphuretted hydrogen are formed.

Bromide of Phosphorus - When bromine & phosphorus are brought into contact in a flask filled with carbonic acid gas they act suddenly on each other with evolution of light & heat & 2 compounds are generated, one a crystalline solid bi-bromide of phosphorus, the other a fluid proto-bromide - Chlorine has a greater affinity for phosphorus than bromine & decomposes both the bromides.

Bromide of Carbon is formed by the action of bromine on periodide of carbon, when bromide of carbon, & subbromide of iodine are formed.

124.
Iodine was discovered in 1812 by M. Courtois. It is obtained from the ~~ash~~ ^{residue} liquor which contains hydriodic acid, which is separated from kelp, the ashes of sea weed, or by treating salt of tungstic acid in a flask & dropping it in a little sulphuric acid. Iodine is a non conductor of electricity, of great spec. gr. ^{sp. gr. of the vapour} 8.749. It is hot & acid to the taste, sparingly soluble in water, but abundantly in alcohol. Iodine is a soft fusible opaque solid, of a bluish black colour & metallic lustre, when heated gives out rich violet coloured vapours. It destroys vegetable colours, though in a less degree than chlorine. It has a strong affinity for pure metals & for simple non-metallic substances, forming compounds termed iodides or iodurets. In its combination it is very analogous to chlorine. It has never been decomposed. It is fused at 225° . Cold solution of starch is a very delicate test of the presence of iodine, forming an insoluble compound of a deep blue colour. According to Stromejer a liquid containing 1-450,000 of its weight of iodine is coloured by starch.

166
compound of Iodine and oxygen. Iodic acid - Discovered by Gay Lussac & Davy. Formed by bringing iodine into contact with protoxide of chlorine. The chlorine unites with 1 portion of iodine, & its oxygen with another, forming a volatile orange coloured matter, chloride of iodine & a white solid substance iodic acid. It is white, semi-transparent & has a strong astringent sour taste, very soluble in water. It fuses at about 500° . With charcoal, sulphur, sugar, &c. it forms mixtures which detonate when heated. With metallic oxides it forms iodates. It is decomposed by sulphurous, phosphorous, & hydriodic acids, & by sulphuretted hydrogen. It is composed of 1 eq. iodine 126 - & 5 oxygen 40 = 166.

127.
Iodine & Hydrogen - Hydriodic acid gas obtained by passing hydrogen & the vapour of iodine through a red hot porcelain tube, or by the action of water on iodide of phosphorus assisted by gentle heat. Oxygen of the water unites with phosphorus, & its hydrogen with iodine, forming phosphoric & hydriodic acids, the latter of which passes over in the form of a colourless gas. It has a sour taste & odour similar to muriatic acid gas. It combines with alkalis forming hydriodates. Water dissolves it in large quantities. It is decomposed by several substances.

oxygen when heated with it unites with its hydrogen & liberates iodine. By adding Chlorine muriatic acid gas is produced & iodine set free in the form of vapour - 100 measures of this gas contain half their volume of hydrogen. $\text{eq: } 127$. Water charged with hydriodic acid forms a colourless solution which emits white fumes: this is readily decomposed by exposure to the atmosphere, the oxygen uniting with the hydrogen forms water & sets iodine free. H_2O acid is frequently met with in nature combined with potash or soda, eq. in many mineral springs, & in salt water.

Chlorides of Iodine. Chlorine is absorbed at common temperature by dry iodine with evolution of caloric forming an orange yellow product Chloride of iodine. It has acid properties, dissolves freely in water alcohol, & ether without change. Perchloride of Iodine is said to be resolved by water into muriatic & Iodic acids.

Iodide of Nitrogen. formed by putting iodine into a solution of ammonia: iodide of nitrogen & hydriodic acid are formed. This like chloride of nitrogen is characterised by its explosive property. It is formed by 1 eq. nitrogen, & 3 of iodine = 392. Iodine also unites with Phosphorus & Sulphur.

15

Sulphur. It occurs as a mineral production.

It is a brittle solid of a greenish yellow colour emits a peculiar odour when rubbed & has little taste. It exists abundantly in combination with some metals, as silver copper, antimony lead, & iron. It is excited negatively by friction. $\text{Sp. gr. } 1.99$. Fus. at 216° but afterwards thickens. It is very volatile. It is insoluble in water but dissolves in boiling oil of turpentine & in alcohol. It forms with oxygen the following compounds.

Hyposulphurous acid	16	8	=	24
Sulphurous acid	— 16	— 16	=	32
Sulphuric acid	— 16	— 24	=	40
Hyposulphuric acid	32	— 40	=	72

³²
Sulphurous Acid gas: it is the sole product
when sulphur is burned in air or dry oxygen
gas. It may be prepared by depriving sulphuric
acid of 1 eq. of its oxygen, as by heating chips
of wood, cork, straw, or some of the metals in
strong sulphuric acid. This is a suffocating, green-
ish gas, fatal to animal life & with not suffi-
cient combustion. Recently boiled water dissolves
about 33 times its volume of the gas. Sulphurous
acid reddens litmus paper & the bleaches it:
it is twice as heavy as oxygen. 100 cu. in. weigh
68.908 grs. 100 cu. in. acid composed of
vapours of sulphur - 100 cu. in. sp. gr. double
oxygen $\frac{100}{100}$
that of oxygen 2.266.

Sulphurous acid has a strong affinity for
oxygen, uniting with it & forming sulphuric acid.
The presence of moisture is essential to this change.
Many of its chemical properties depend on this
affinity for oxygen. When mixed with peroxide
of iron in solution by depriving it of part of its
ox: it converts it into protoxide. Nitric acid
by yielding some of its ox: converts it into sul-
phuric acid. It is condensed more readily of all
the gases, a force equal to two atmospheres being
sufficient. The anhydrous liquid acid boils at
14° & from the rapidity of its evaporation pro-
duces intense cold. With metallic oxides it
forms sulphites.

⁴⁰
Sulphuric Acid - oil of Vitriol. It is obtained in
Britain & most parts of the continent by burning
sulphur previously mixed with $\frac{1}{8}$ of its weight
of nitrate of potash: the gaseous product is
conducted into a leaden chamber containing
a little water. The nitric acid yields oxygen
to a portion of sulphur & converts it into
sulphuric acid which combines with the potash,
while the greater part of the sulphur forms
sulphurous acid by uniting with the oxygen
of the air. This is not quite pure, containing
sulphate of potash & lead which must be se-
parated by distillation. Pure sulph. acid is a
dense colourless fluid, boils at 620°, sp. gr. 1.847
& freezes at 15°. When diluted with water at 32°

Second Course.

PART I.

THE PRINCIPLES, PROCESSES, AND PRODUCTS OF INORGANIC CHEMISTRY.

IN here recapitulating the properties of the non-metallic elements, a different arrangement has been adopted; and the experimental illustrations will be, as much as possible, varied. In the first course, they have been classed according to the agreement of certain of their physical properties; it being thought that the strong contrasts which the classes therein present to one another, may impress themselves strongly upon the mind, which has been supposed not yet prepared for a more scientific arrangement.

In this second course, the electro-polar arrangement has been adopted; and the students who attend during the whole session will, thus, have the advantage of examining the most interesting and

instructive department of the science, from different points of view : while they who enter only for this division are supposed to be already sufficiently acquainted with the connecting points of Physics, but will have the whole field of pure Chemistry displayed before them.

I. INTRODUCTORY REMARKS. (a) Chemical attraction. (b) Composition. (c) Decomposition. (d) Equivalents. (e) Influence of electrical forces.

1. *Electro-Negative Elements.* (a) Oxygen. (b) Chlorine. (c) Iodine. (d) Bromine. (e) Fluorine.

2. *Electro-positive Non-metallic Elements.* (a) Hydrogen. (b) Nitrogen. (c) Carbon. (d) Boron. (e) Silicon. (f) Phosphorus. (g) Sulphur. (h) Selenium.

3. *Metals.*

1. ELECTRO-NEGATIVE ELEMENTS AND THEIR BINARY COMPOUNDS WITH EACH OTHER.

II. OXYGEN. (a) Combustion. (b) Oxi-acids. (c) Bases. (d) Equivalent.

III. CHLORINE. (a) Preparation. (b) Properties.

1. *Compounds of Chlorine.* (a) Protoxide of chlorine. (b) Peroxide of chlorine. (c) Chloric acid. (d) Per-chloric acid.

It is the strongest of the acids - It decomposes all animal & vegetable substances by the aid of heat setting carbon free. It has a strong affinity for water, uniting with it in every proportion. By passing it through a red hot porcelain tube it is decomposed & resolved into 2 measures of sulphurous acid & 1 oxygen. & is composed

Sulphur	16	- or 1 eq	} = 40
Oxygen	24	- 3 eq	

Mercurate of baryta is a sure test for this acid, sulphate of baryta being formed on adding the baryta to the acid, which is insoluble in acids & alkalis.

48 (Thomson)

Hyposulphurous acid. Formed by passing a current of sulphurous acid through a solution of hydrosulphuret of lime or strontia. The acid is deprived of $\frac{1}{2}$ of its ox. by the hydrogen of the sulphuretted hydrogen & the other $\frac{1}{2}$ unites with the sulphur of the sulph. hyd. forming hyposulphurous acid. It may also be obtained by the action of sulphurous acid on iron filings. The salts formed by it are termed hyposulphites. It appears to be formed of 2 atoms of sulphur & 2 oxygen = 48 instead of 24.

72

Hyposulphuric acid, is formed by transmitting a current of sulphurous acid gas through water containing peroxide of manganese in fine powder. The manganese yields oxygen to the sulphurous acid, converting it into sulphuric, and another into hyposulphuric acid. It has no odour & forms soluble salts with baryta, strontia lime &c. while sulphuric acid forms insoluble salts. It is formed of 2 eq. sulphur 32 and 5 of oxygen 40 = 72.

Compound of Hydrogen & Sulphur.
Sulphuretted Hydrogen. May be formed
either by heating sulphur of antimony in a retort
with 10 or 12 times its weight of muriatic acid by
which hydrogen attracts the sulphur, oxygen to
antimony, & muriatic acid the protoxide of
antimony: or by the action of diluted sulphuric
acid on protosulphuret of iron. It is a colourless
gas, of very offensive smell & very injurious to
animal life. It extinguishes flame, but burns
at the mouth of the vessel with a pale blue flame
& sulphur is deposited. With oxygen it forms
a mixture which detonates on the application
of heat or the electric spark. It tarnishes metals.
It is absorbed by water & communicates its peculiar
smell. 100 cu. in. weigh 36.6074 grs. sp. g. 1.1805
Very minute quantities of lead, silver & mercury,
are detected by this gas. It is formed of 1 eq:
sulphur & 1 hydrogen = 17. has decidedly acid
properties. On exposing it to the air the oxygen of
the latter unites with its hydrogen forming water
& sulphur is deposited. Sulphur & hydrogen
and sulphurous acid decompose each
other & hydro sulphurous acid is formed.
Chlorine, iodine & bromine also decompose it.

Persulphuretted Hydrogen - Persulphuretted
hydrogen? (Turpin) formed by boiling equal
parts of recently blaked lime & flowers of sulphur
with 5 or 6 of water. The liquid is then poured
into diluted muriatic acid, & the sulphur
is deposited, & the sulphuretted hydrogen
combining with it forms persulph: hyd:
At common temperatures it is a viscid
liquid of a yellow colour, sp. gr. 1.769 - it has
the odour & taste of sulph: hydrogen. According
to Dalton it is formed of 2 eqs of sulphur & 1 of
hydrogen. It is regarded as an acid.

10
Phosphorus - Discovered 1669. Originally prepared from urine, but afterwards from bones. The object is to bring phosphoric acid in contact with charcoal at a strong red heat. The charcoal takes ox: from the phosphoric acid, carbonic acid is disengaged, & phosphorus set free. Calcined bones should be used, & digested for a day or two with $\frac{1}{2}$ their weight of sulphuric acid, a little water being added so as to form a thin paste. The phos: of lime is decomposed by the acid & 2 new salts generated, the neutral sulphate, & soluble superphosphate of lime: by adding boiling water & filtering the latter is separated. The solution is then evaporated to the consistency of syrup, mixed with $\frac{1}{4}$ its weight of powdered charcoal, & heated in a retort the neck of which is put into water & the phosphorus as it passes over in the form of vapour collected. Pure phosph: is transparent & almost colourless. Sp. gr. 1.77 - It is highly inflammable, & on exposure to the atmosphere slow combustion takes place from its combination with oxygen. It fuses at 108° .

Compounds of phosphorus & oxygen
Phosphorous, & Phos^{ic} acids

Phosphorous acid may be conveniently prepared by subliming phosphorus through powdered corrosive sublimate (chloride of mercury) contained in a glass tube: protochloride of phosphorus is formed, by adding water to which a neutral decomposition takes place: the hydrogen of the water unites with the chlorine forming muriatic acid, while the oxygen combines with the phosphorus, forming phosphorous acid. When phosphorus is heated in highly rarefied air

a white volatile powder is formed, sup-
posed to be the anhydrous acid; when
brought into contact with oxygen-
phosphoric acid is formed. It dissolves
readily in water & unites to alkalis
forming phosphites. It is composed of 1
eq: phosphorus 16 & $1\frac{1}{2}$ of oxygen 12 = 28.

36
Phosphoric Acid, and Pyro³⁶phosphoric
acid. These compounds afford us instances
of two substances consisting of the same
ingredients in the same proportions, yet
differing essentially in chemical properties.
Berzelius has termed these isomeric com-
pounds. These acids may either be obtained
by the oxidation of phosphorus, or by the
action of sulphuric acid on calcined bones.
When phosphorus is burned in a dry
vessel of air or oxygen gas a copious white
smoke appears which falls to the bottom
of the vessel like flakes of snow; this is
anhydrous pyro-phosphoric acid, on
exposure to the air for a day or two it
rapidly absorbs moisture & becomes
phosphoric acid. It may be procured
also by dropping bits of phosph: into strong
nitric acid; the water is decomposed, the
oxygen unites with the phosph: & its hydrogen
with the nitrogen of the acid. The composition
of these 2 acids is identical. They are formed
by 1 eq: phosph: 16 & $2\frac{1}{2}$ of oxygen 20 = 36.
Phos³⁶ acid yields a yellow salt with oxide
of silver & does not disturb the transparency
of albumen, while pyro-phos³⁶ yields a white
salt & albumen is precipitated by it.

IV. IODINE, (a) Preparation. (b) Properties.

1. *Compounds of Iodine.* (a) Iodic acid. (b) Chloriodic acid.

V. BROMINE. (a) Preparation. (b) Properties.

1. *Compounds of Bromine.* (a) Bromic acid. (b) Chloro-bromic acid, &c.

2. ELECTRO-POSITIVE NON-METALLIC ELEMENTS, AND THEIR BINARY COMPOUNDS WITH THE ELECTRO-NEGATIVE.

VI. HYDROGEN. (a) Preparation. (b) Properties.

1. *Compounds of Hydrogen with Oxygen.* (a) Water. (b) Deutoxide of Hydrogen.
2. *Hydro-Acids.* (a) Muriatic acid. (b) Hydriodic acid. (c) Hydro-bromic acid. (d) Hydro-fluoric acid.

VII. NITROGEN. (a) Preparation. (b) Properties.

1. *Compounds of Nitrogen with Oxygen.* (a) Atmospheric air. (b) Protoxide of nitrogen. (c) Deutoxide of nitrogen. (d) Nitrous acid. (e) Nitric acid. (f) Hypo-nitrous acid.
2. *Other Compounds of Nitrogen.* (a) Chloride of nitrogen, &c.

VIII. CARBON. (a) Preparation. (b) Properties. (c) Varieties.

1. *Compounds of Carbon and Oxygen.* (a) Carbonic oxide. (b) Carbonic acid. (c) Oxalic acid.
2. *Other Compounds of Carbon.* (a) Perchloride of carbon. (b) Proto-chloride of carbon. (c) Sub-chloride of carbon, &c.

IX. BORON. (a) Preparation. (b) Properties.

1. *Compounds of Boron.* (a) Boracic acid. (b) Fluo-boracic acid, &c.

X. SILICON. (a) Preparation. (b) Properties.

1. *Compounds of Silicon.* (a) Silica. (b.) Fluo-silicic acid, &c.

XI. PHOSPHORUS. (a) Preparation. (b) Properties.

1. *Compounds of Phosphorus and Oxygen.* (a) Oxide of phosphorus. (b) Phosphoric acid. (c) Phosphorous acid. (d) Hypo-phosphorous acid.
2. *Other Compounds of Phosphorus.* (a) Perchloride of phosphorus. (b) Proto-chloride of phosphorus, &c.

XII. SULPHUR. (a) Preparation. (b) Properties.

1. *Compounds of Sulphur and Oxygen.* (a) Sulphurous acid. (b) Sulphuric acid. (c) Hypo-sulphurous acid. (d) Hypo-sulphuric acid.
2. *Other Compounds of Sulphur.*



1. Compounds of Carbon and Oxygen. (a) Carbonic oxide. (b) Carbonic acid. (c) Oxalic acid.
2. Other Compounds of Carbon. (a) Peroxide of carbon. (b) Proto-chloride of carbon. (c) Sub-chloride of carbon, &c.

III. BORON. (a) Preparation. (b) Properties.

1. Compounds of Boron. (a) Boric acid. (b) Fluor-boric acid, &c.

IV. SILICON. (a) Preparation. (b) Properties.

1. Compounds of Silicon. (a) Silica. (b) Fluor-silicic acid, &c.

V. PHOSPHORUS. (a) Preparation. (b) Properties.

1. Compounds of Phosphorus and Oxygen. (a) Oxide of phosphorus. (b) Phosphoric acid. (c) Hypophosphorous acid. (d) Hypo-phosphorous acid.
2. Other Compounds of Phosphorus. (a) Proto-chloride of phosphorus. (b) Proto-chloride of phosphorus, &c.

VI. SULPHUR. (a) Preparation. (b) Properties.

1. Compounds of Sulphur and Oxygen. (a) Sulphurous acid. (b) Sulphuric acid. (c) Hypo-sulphurous acid. (d) Hypo-sulphuric acid.
2. Other Compounds of Sulphur.

XIII. SELENIUM

1. Compounds of Selenium and Oxygen (a) Selenic acid (b) Selenous acid (c) Selenic acid

2. Other Compounds of Selenium

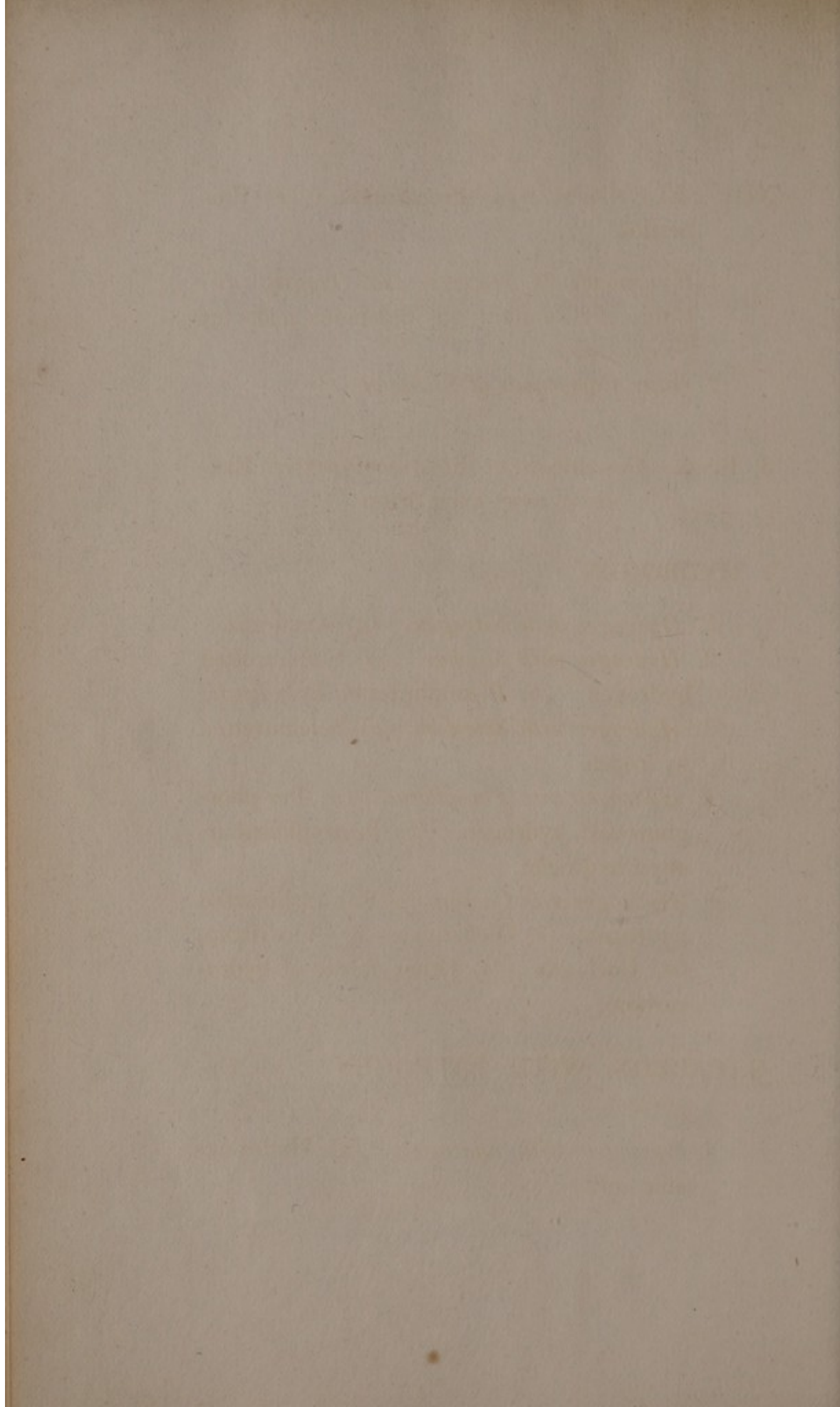
3. Binary Compounds of Selenium with other Elements

C. HYDROGEN

1. Hydrogen with Nitrogen (a) Ammonia
2. Hydrogen with Sulphur (a) Sulphuretted hydrogen (b) Bisulphuretted hydrogen
3. Hydrogen with Selenium (a) Selenuretted hydrogen
4. Hydrogen with Phosphorus (a) Phosphuretted hydrogen (b) Hypophosphuretted hydrogen
5. Hydrogen with Carbon (a) Substituted hydrocarbons (b) Olefin gas (c) Acetylene (d) Coal gas (e) Other forms of hydrocarbon

IV. CARBON WITH NITROGEN (a) Cyanogen

1. Cyanogen with Hydrogen (a) Hydrocyanic acid



XIII. SELENIUM. (a) Preparation. (b) Properties.

- 1 *Compounds of Selenium and Oxygen.* (a) Oxide of Selenium. (b) Selenious acid. (c) Selenic acid.

2 *Other Compounds of Selenium.*

3. BINARY COMPOUNDS OF ELECTRO-POSITIVE ELEMENTS WITH EACH OTHER.

I. HYDROGEN.

1. *Hydrogen with Nitrogen.* (a) Ammonia.
2. *Hydrogen with Sulphur.* (a) Sulphuretted hydrogen. (b) Bi-sulphuretted hydrogen.
3. *Hydrogen with Selenium.* (a) Seleniuretted hydrogen.
4. *Hydrogen with Phosphorus.* (a) Per-phosphuretted hydrogen. (b) Proto-phosphuretted hydrogen.
5. *Hydrogen with Carbon.* (a) Sub-carburetted hydrogen. (b) Olefiant gas. (c) Fire damp. (d) Coal gas. (e) Other forms of hydrocarbon.

II. CARBON WITH NITROGEN. (a) Cyanogen.

- 1 *Cyanogen with hydrogen.* (a) Hydro-cyanic acid.

2. *Cyanogen with Oxygen.* (a) Cyanous acid.
(b) Cyanic acid. (c) Fulminic acid.
3. *With other Electro-Negative Elements.* (a)
Chloro-cyanic acid. (b) Iodide of cyanogen.
4. *With Electro Positive Elements.* (a)
Sulpho-cyanic acid. (b) Ferro-cyanic acid.

III. SULPHUR WITH CARBON. (a) Bi-sulphuret of carbon. (b) Xanthogen.

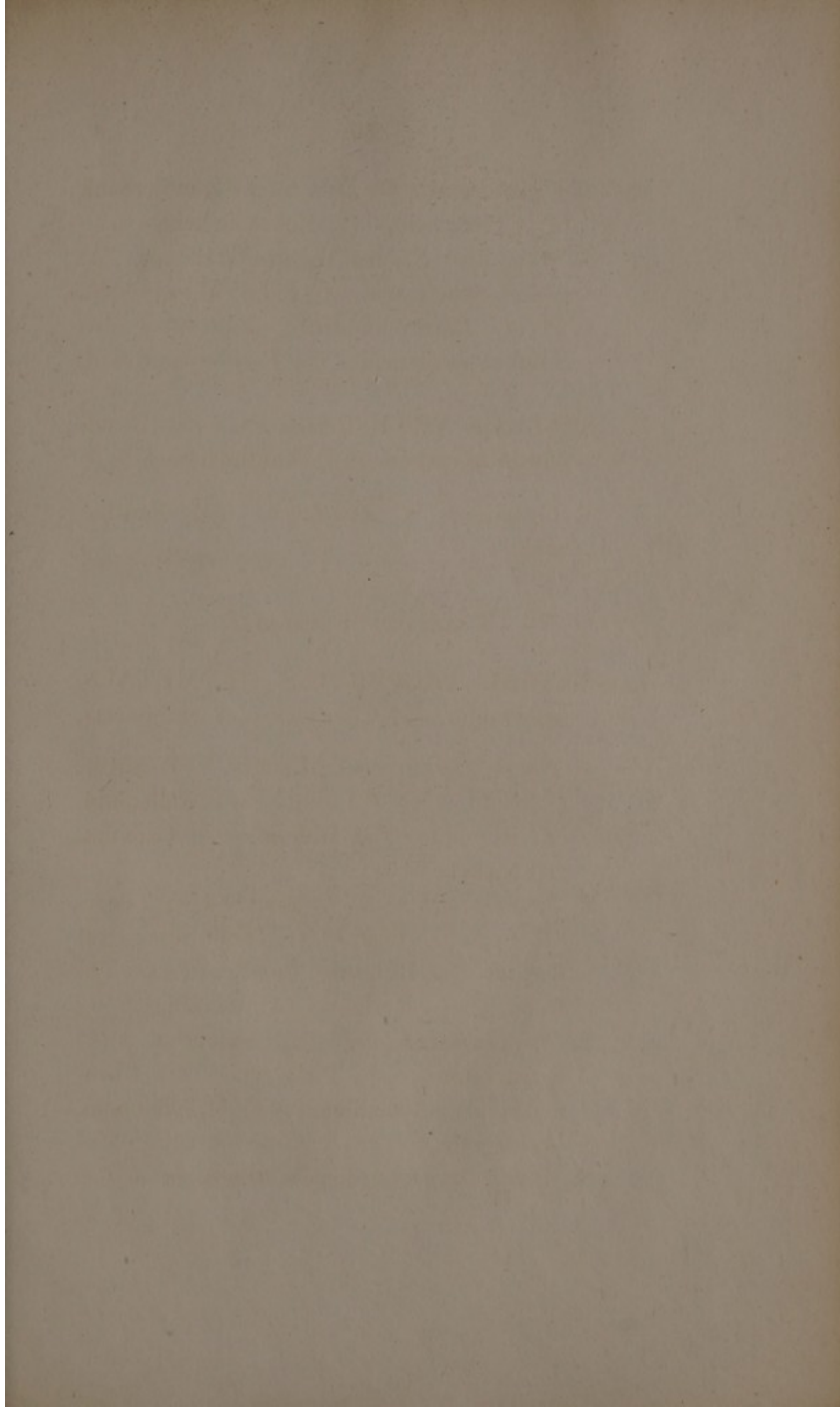
1. *Compounds of Xanthogen.* (a) Xanthic acid.

4 METALLIC ELEMENTS.

I. GENERAL PROPERTIES OF METALS.

(a) Oxides. (b) Chlorides. (c) Sulphurets.

1. *Noble Metals.* (a) Mercury. (b) Silver.
(c) Gold. (d) Platinum. (e) Palladium.
(f) Rhodium. (g) Iridium. (h) Osmium.
(i) Nickel.
2. *Metals which retain Oxygen at high Temperatures.* (a) Lead. (b) Tellurium. (c)
Copper (d) Bismuth. (e) Titanium. (f)
Cobalt. (g) Cerium. (h) Uranium.
3. *Acidifiable Metals.* (a) Antimony. (b)
Columbium. (c) Tungsten. (d) Chromium. (e) Vanadium. (f) Molybdenum.
(g) Arsenic.
4. *Metals which decompose Water at a Red*



1. Chlorine (a) Test (b) Preparation
 Calcium (c) Magnesium
 2. Hydrochloric Acid (a) Preparation (b)
 Sodium (c) Lithium (d) Potassium
 Barium (e) Strontium
 3. Sulfuric Acid (a) Preparation (b)
 Yttrium (c) Zirconium (d) Uranium
 (e) Zinc (f) Tin

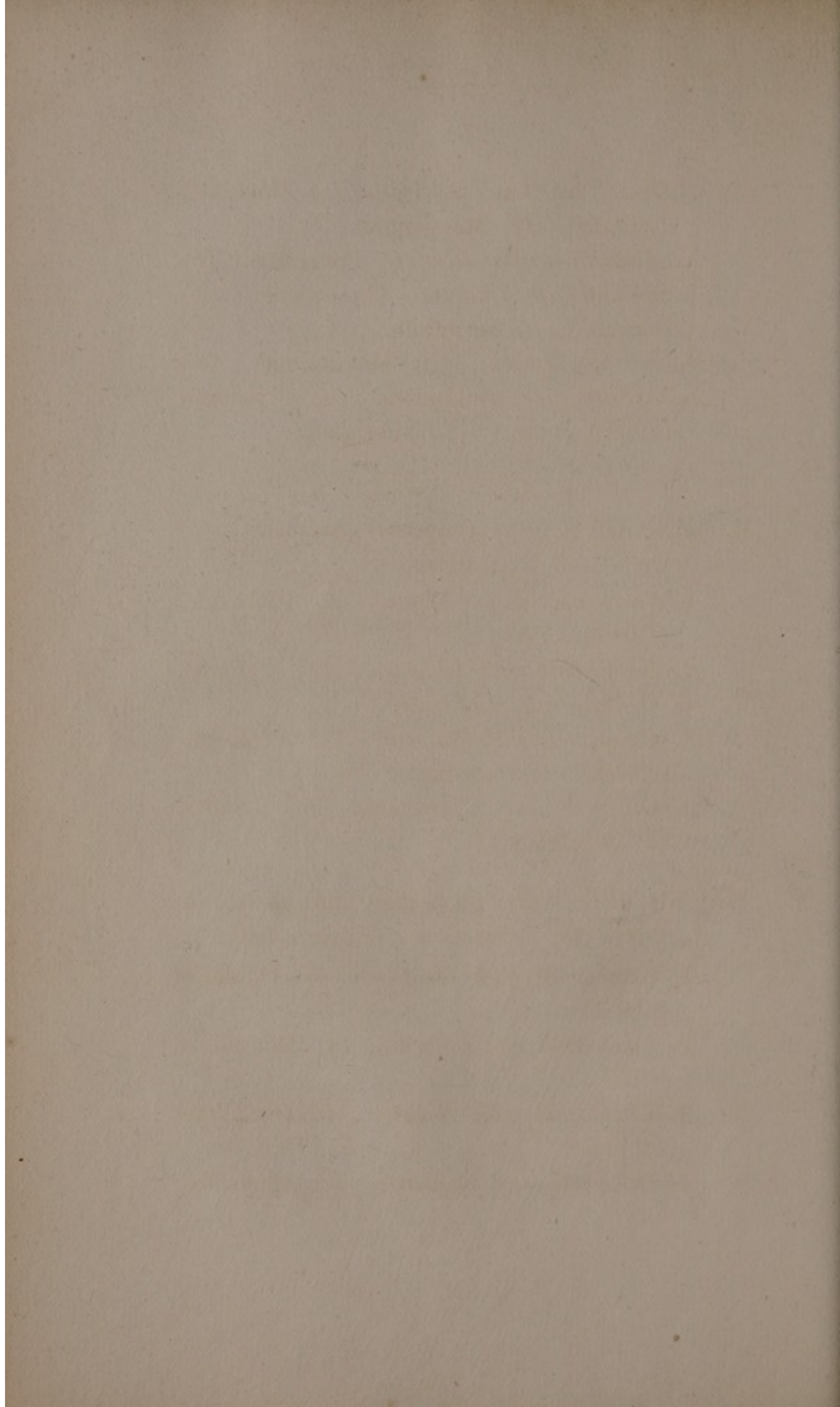
4. Nitric Acid

- II. MERCURY (a) Preparation and uses (b)
 Oxide (c) Extraction

1. Compounds with Oxygen (a) Peroxide
(b) Peroxide
2. Compounds with Chlorine (a) Chloride
(b) Chloride
3. Compounds with Sulfur (a) Sulfide
(b) Sulfide
4. Other Heavy Compounds (a) Sulfide
(b) Sulfide

- III. SILVER (a) Preparation and uses (b)
 Oxide (c) Extraction (d) Sulfide

1. Compounds with Oxygen (a) Oxide of Silver
2. Compounds with Chlorine (a) Chloride of Silver
3. Compounds with Sulfur (a) Sulfide of Silver
4. Other Heavy Compounds (a) Sulfide



- Heat.* (a) Tin. (b) Iron. (c) Zinc. (d) Cadmium. (e) Manganese.
5. *Alkalifiable Metals.* (a) Potassium. (b) Sodium. (c) Lithium. (d) Calcium. (e) Barium. (f) Strontium.
6. *Earthy Metals.* (a) Magnesium. (b) Yttrium. (c) Aluminum. (d) Glucinum. (e) Zirconium. (f) Thorium.

1. NOBLE METALS.

II. MERCURY. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Compounds with Oxygen.* (a) Protoxide. (b) Peroxide.
2. *Compounds with Chlorine.* (a) Calomel. (b) Corrosive Sublimate.
3. *Compounds with Sulphur.* (a) Proto-sulphuret. (b) Cinnabar.
4. *Other Binary Compounds.* (a) Iodides. (b) Amalgams, &c.

III. SILVER. (a) Properties and uses. (b) Ores. (c) Extraction. (d) Assaying.

1. *Compounds with Oxygen.* (a) Oxide of Silver.
2. *Compounds with Chlorine.* (a) Chloride of Silver.
3. *Compounds with Sulphur.* (a) Sulphuret of Silver.
4. *Other Binary Compounds.* (a) Alloys, &c.

IV. GOLD. (a) Properties and uses. (b) Ores.
(c) Extraction. (d) Parting.

1. *Compounds with Oxygen.* (a) Oxide of Gold.
2. *Compounds with Chlorine.* (a) Chlorides of gold.
3. *Compounds with Sulphur.* (a) Per-sulphuret of gold.
4. *Other Binary Compounds.* (a) Alloys, &c.

V. PLATINUM. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.* (a) Alloys, &c.

VI. PALLADIUM. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

VII. RHODIUM. (a) Properties and uses. (b) Ores. (c) Extraction.

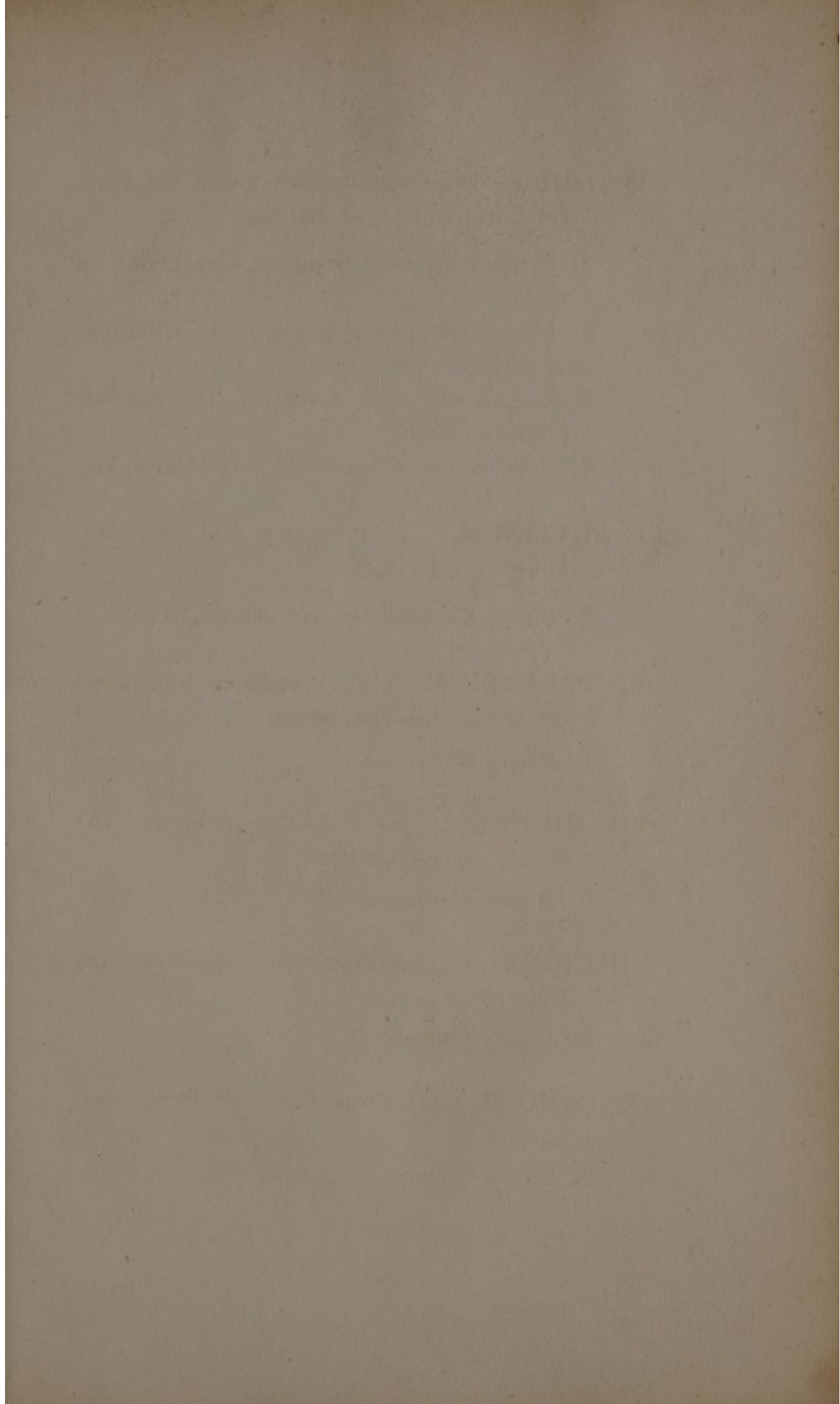
1. *Binary Compounds.*

VIII. IRIDIUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

IX. OSMIUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*



IV. CARBON. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Charcoal and Graphite. (a) Preparation. (b) Properties and uses.
2. Lampblack and Bone Black. (a) Preparation. (b) Properties and uses.
3. Carbons with Impurities. (a) Preparation. (b) Properties and uses.
4. Other forms of carbon. (a) Preparation. (b) Properties and uses.

V. FLUORINE. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Heavy Compounds. (a) Preparation. (b) Properties and uses.

VI. PHOSPHORUS. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Heavy Compounds. (a) Preparation. (b) Properties and uses.

VII. ARSENIC. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Heavy Compounds. (a) Preparation. (b) Properties and uses.

VIII. ANTIMONY. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Heavy Compounds. (a) Preparation. (b) Properties and uses.

IX. BISMUTH. (a) Properties and uses. (b) Occurrence. (c) Preparation.

1. Heavy Compounds. (a) Preparation. (b) Properties and uses.

X. **WATER** (a) Hydrogen and oxygen (b) Water
(c) Properties

1. Heavy Hydrogen (a) Heavy Hydrogen

2. Heavy Water (a) Heavy Water (b) Heavy
Tetraoxide

XI. **HEAT** (a) Heat (b) Heat (c) Heat
(d) Heat

1. Calorimeter (a) Calorimeter (b) Calorimeter

(c) Calorimeter (d) Calorimeter

2. Calorimeter with (a) Calorimeter (b) Calorimeter

(c) Calorimeter (d) Calorimeter

3. Calorimeter with (a) Calorimeter (b) Calorimeter

(c) Calorimeter (d) Calorimeter

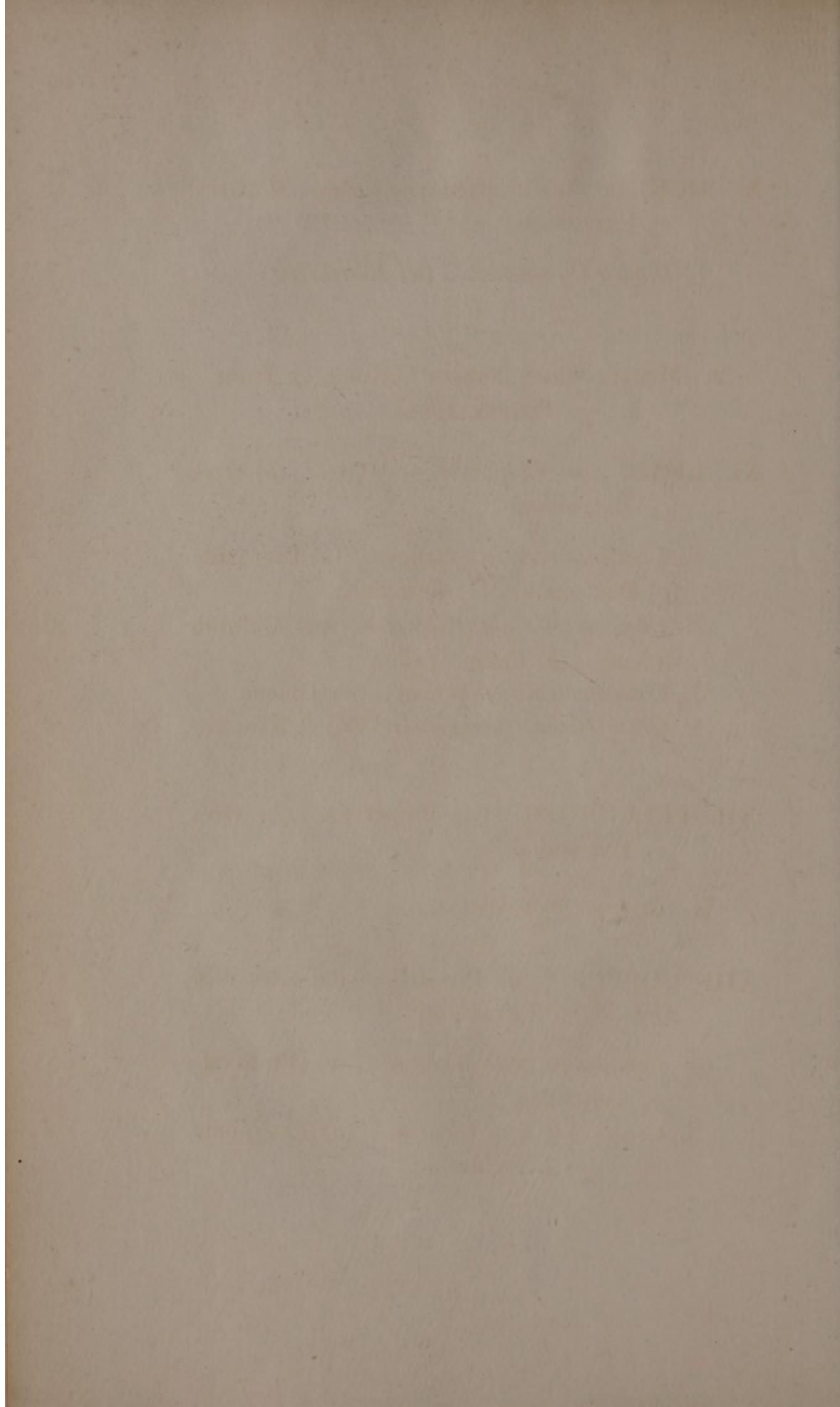
XII. **TELLURIDE** (a) Telluride (b) Telluride
(c) Telluride

1. Heavy Telluride

XIII. **COPPER** (a) Copper (b) Copper (c) Copper
(d) Copper

1. Copper (a) Copper (b) Copper (c) Copper
(d) Copper

2. Copper (a) Copper (b) Copper (c) Copper
(d) Copper



X. NICKEL. (a) Properties and uses. (b) Ores.
(c) Extraction.

1. *Binary Compounds.* (a) Alloys, &c.

2. METALS WHICH RETAIN OXYGEN AT HIGH
TEMPERATURES.

XI. LEAD. (a) Properties and uses. (b) Ores.
(c) Extraction.

1. *Combinations with Oxygen.* (a) Protoxide.
(b) Deutoxide. (c) Peroxide.

2. *Combinations with Chlorine.* (a) Chloride
of lead. (b) Patent Yellow.

3. *Compounds with Sulphur.* (a) Galena.

4. *Other Binary Compounds.* (a) Alloys, &c.

XII. TELLURIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. *Binary Compounds.*

XIII. COPPER. (a) Properties and uses. (b)
Ores. (c) Extraction.

1. *Compounds with Oxygen.* (a) Protoxide.
(b) Peroxide.

2. *Compounds with Chlorine.* (a) Proto-chlo-
ride. (b) Per-chloride.

3. *Compounds with Sulphur.* (a) Proto-sulphuret. (b) Bi-sulphuret.

4. *Other Binary Compounds.* (a) Alloys, &c.

XIV. BISMUTH. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.* (a) Alloys, &c.

XV. TITANIUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

XVI. COBALT. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

XVII. CERIUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

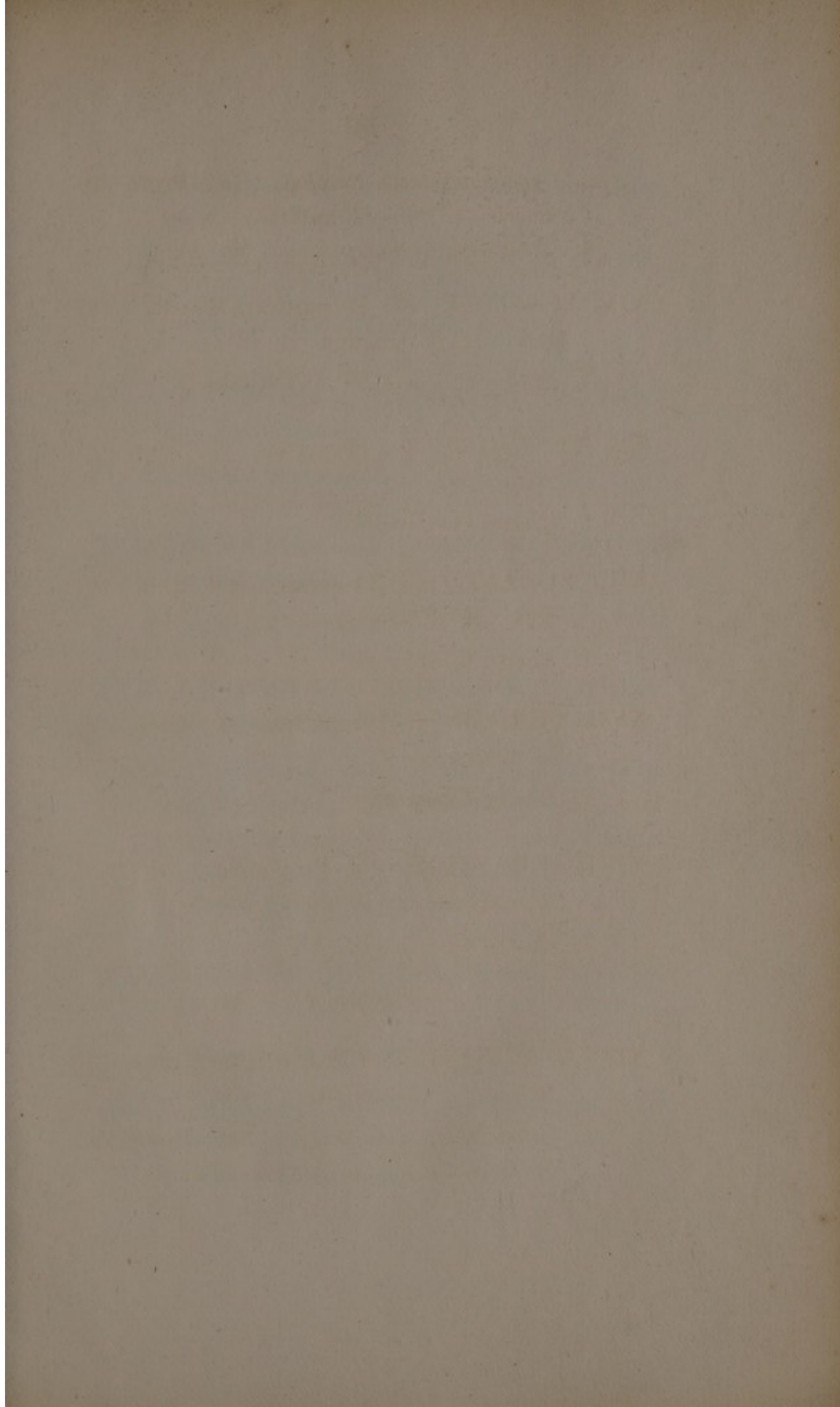
XVIII. URANIUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

3. ACIDIFIABLE METALS.

XIX. ANTIMONY. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Compounds with Oxygen.* (a) Protoxide. (b) Deutoxide. (c) Antimonic acid.



3. Compounds with Sulphur. (c) Proto-sulphides. (d) Bisulphides.

4. Other Heavy Compounds. (e) Alloys, &c.

XIV. NICKEL. (a) Properties and uses. (b) Ores. (c) Extraction.

1. Heavy Compounds. (e) Alloys, &c.

XV. TITANIUM. (a) Properties. (b) Ores. (c) Extraction.

1. Heavy Compounds.

XVI. COBALT. (a) Properties and uses. (b) Ores. (c) Extraction.

1. Heavy Compounds.

XVII. CERIUM. (a) Properties. (b) Ores. (c) Extraction.

1. Heavy Compounds.

XVIII. URANIUM. (a) Properties. (b) Ores. (c) Extraction.

1. Heavy Compounds.

2. Uranium Salts.

XIX. ANTIMONY. (a) Properties and uses. (b) Ores. (c) Extraction.

1. Compounds with Oxygen. (d) Protoxide. (e) Sesquioxide. (f) Antimony acid.

2. Compounds with Chlorine. (a) Perochloride
acid. (b) Per-chlorate.
3. Compounds with Sulphur. (a) Free sul-
phur. (b) Sulphur compound.
4. Other Binary Compounds.

XX. COLUMBIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. Binary Compounds.

XXI. TUNGSTEN. (a) Properties. (b) Ores.
(c) Extraction.

1. Binary Compounds.

XXII. CHROMIUM. (a) Properties. (b) Ores.
(c) Extraction.

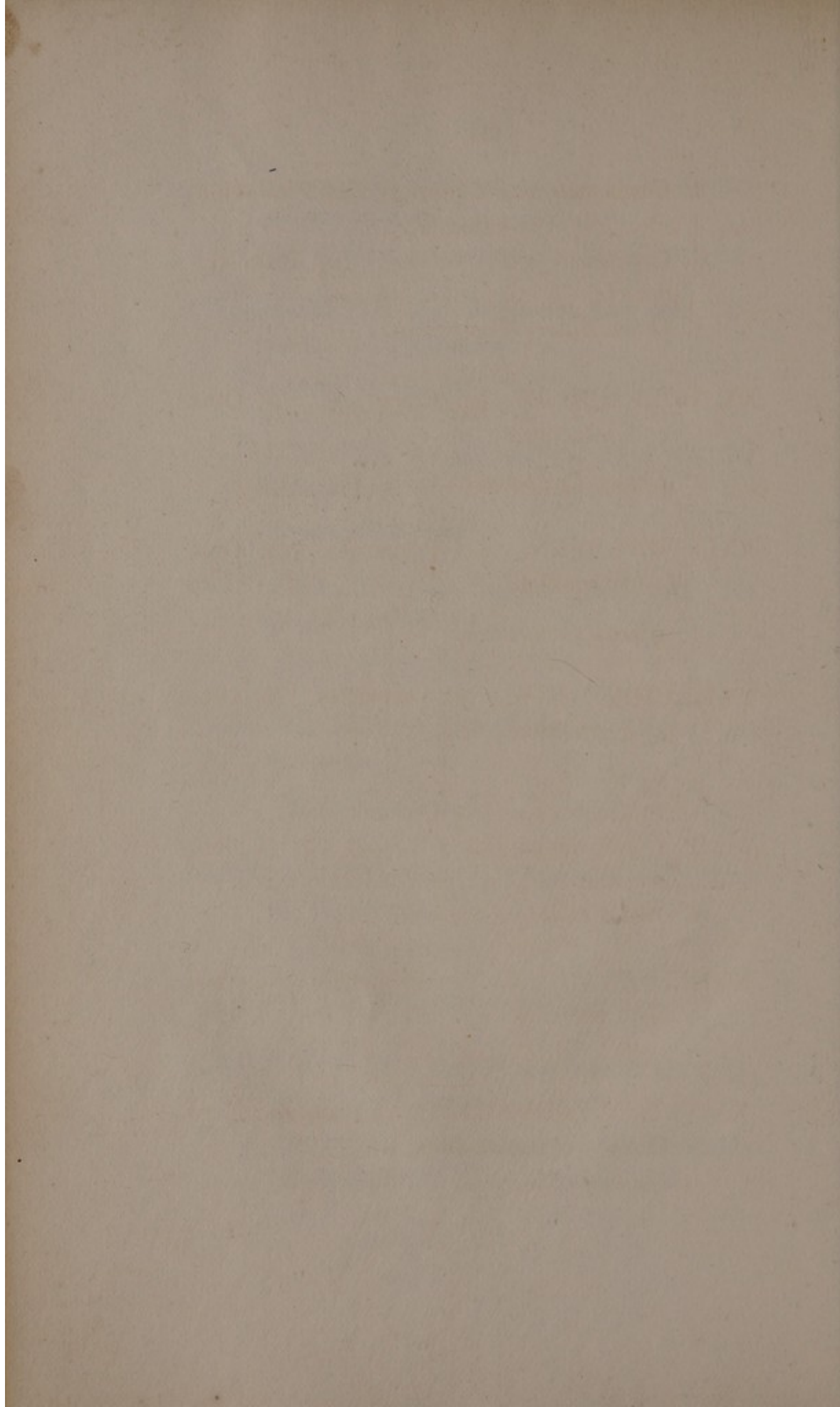
1. Compounds with Oxygen. (a) Peroxide.
(b) Dioxide. (c) Chromic acid.
2. Compounds with Chlorine. (a) Chloro-
chromic acid. (b) Per-chloride.
3. Other Binary Compounds.

XXIII. VANADIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. Binary Compounds.

XXIV. MOLYBDENUM. (a) Properties. (b)
Ores. (c) Extraction.

1. Binary Compounds.



2. *Compounds with Chlorine.* (a) Proto-chloride. (b) Per-chloride.
3. *Compounds with Sulphur.* (a) Proto-sulphuret. (b) Golden sulphuret.
4. *Other Binary Compounds.*

XX. COLUMBIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. *Binary Compounds.*

XXI. TUNGSTEN. (a) Properties. (b) Ores.
(c) Extraction.

1. *Binary Compounds.*

XXII. CHROMIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. *Combinations with Oxygen.* (a) Protoxide. (b) Deutoxide. (c) Chromic acid.
2. *Combinations with Chlorine.* (a) Chloro-chromic acid. (b) Per-chloride.
3. *Other Binary Compounds.*

XXIII. VANADIUM. (a) Properties. (b) Ores.
(c) Extraction.

1. *Binary Compounds.*

XXIV. MOLYBDENUM. (a) Properties. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

XXV. ARSENIC. (a) Properties and uses. (b) Ores. (c) Attraction.

1. *Combinations with Oxygen.* (a) Protoxide of arsenic. (b) Arsenious acid. (c) Arsenic acid.

2. *Other Binary Compounds.*

A. *Poisoning by Arsenic.* (a) Tests, &c.

4. METALS WHICH DECOMPOSE WATER AT A RED HEAT.

XXVI. TIN. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Combinations with Oxygen.* (a) Protoxide. (b) Peroxide.

2. *Combinations with Chlorine.* (a) Protochloride. (b) Per-chloride.

3. *Other Binary Compounds.* (a) Alloys.

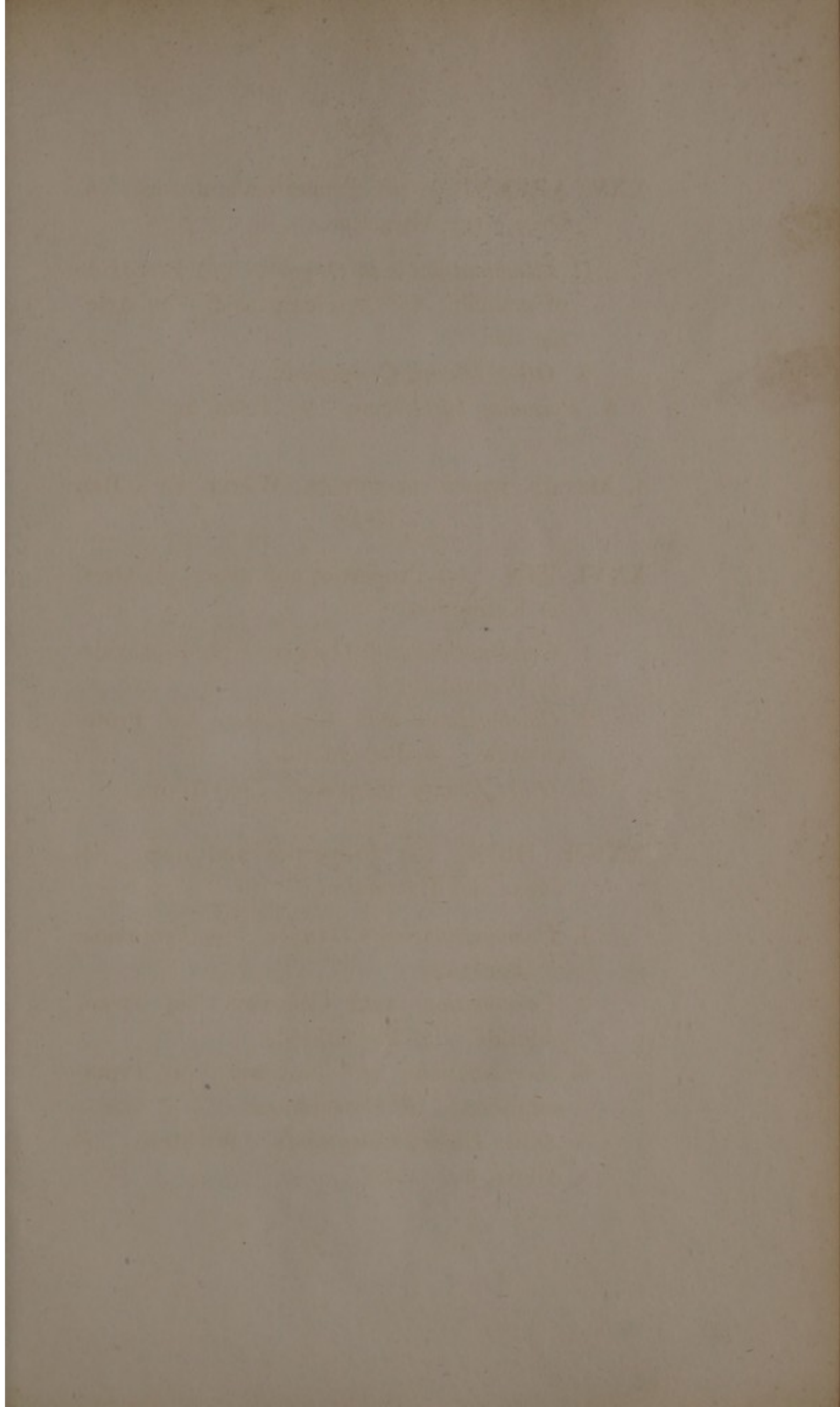
XXVII. IRON. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Combinations with Oxygen.* (a) Protoxide. (b) Peroxide.

2. *Combinations with Chlorine.* (a) Protochloride. (b) Per-chloride.

3. *Combinations with Sulphur.* (a) Proto-sulphuret. (b) Bi-sulphuret.

4. *Other Binary Compounds.* (a) Steel. (b) Alloys, &c.



XXVIII. ZINC. (a) Prepared by heating zinc
oxide in hydrogen.

1. Binary Compounds (a) Zinc

XXIX. CADMIUM. (a) Prepared by heating
oxide in hydrogen.

1. Binary Compounds

XXX. MANGANESE. (a) Prepared by heating
oxide in hydrogen.

1. Binary Compounds

2. Amalgams

XXXI. POTASSIUM. (a) Prepared by heating
oxide in hydrogen.

1. Binary Compounds (a) Potassium

XXXII. SODIUM. (a) Prepared by heating
oxide in hydrogen.

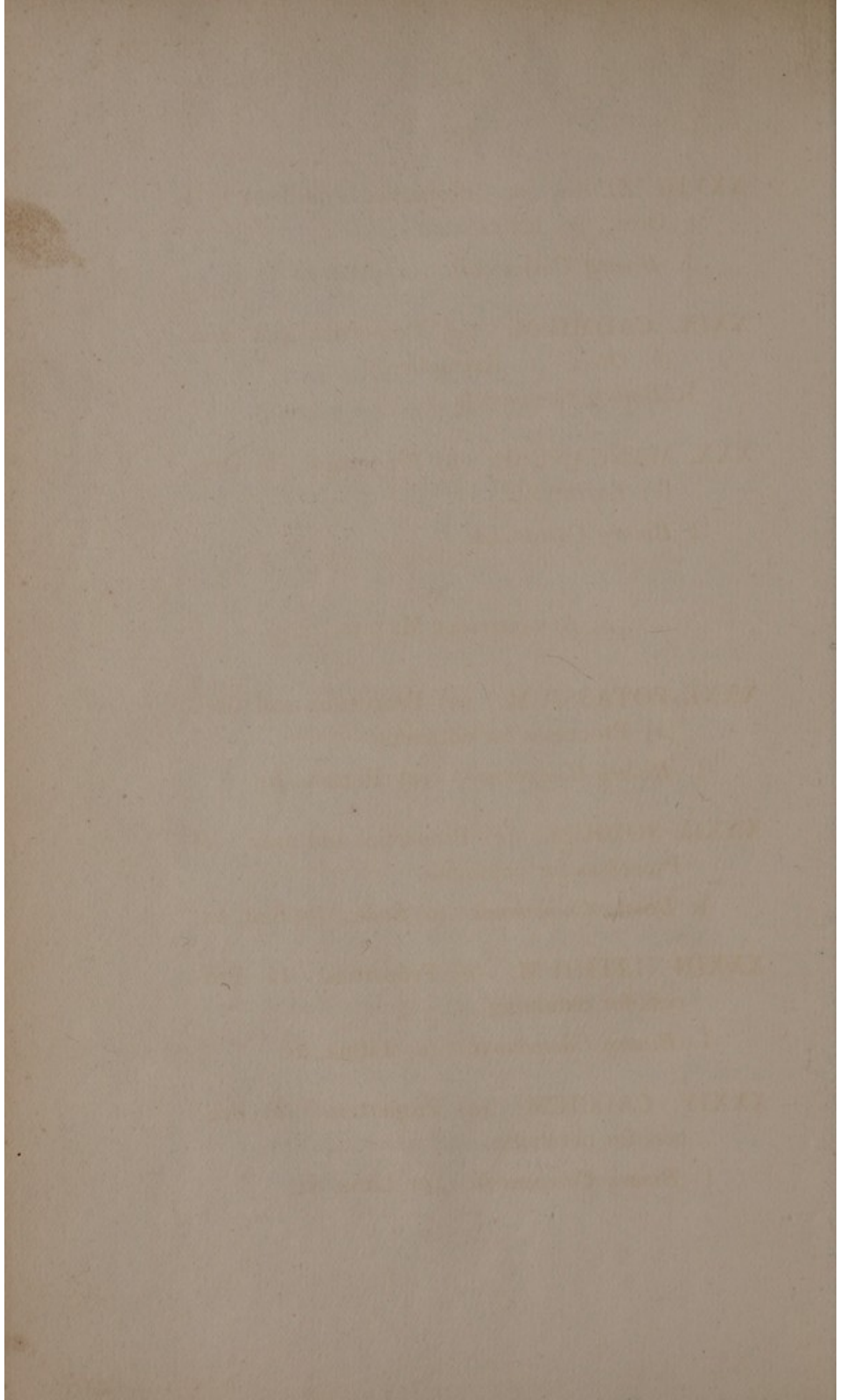
1. Binary Compounds (a) Sodium

XXXIII. LITHIUM. (a) Prepared by heating
oxide in hydrogen.

1. Binary Compounds (a) Lithium

XXXIV. CALCIUM. (a) Prepared by heating
oxide in hydrogen.

1. Binary Compounds (a) Calcium



XXVIII. ZINC. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.* (a) Alloys.

XXIX. CADMIUM. (a) Properties and uses. (b) Ores. (c) Extraction.

1. *Binary Compounds.*

XXX. MANGANESE. (a) Properties. (b) Ores. (c) Extraction.

1 *Binary Compounds.*

5. ALKALIFIABLE METALS.

XXXI. POTASSIUM. (a) Properties and uses. (b) Processes for obtaining.

1. *Binary Compounds.* (a) Potassa, &c

XXXII. SODIUM. (a) Properties and uses. (b) Processes for obtaining.

1. *Binary Compounds.* (a) Soda. (b) Salt, &c.

XXXIII. LITHIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds,* (a) Lithia, &c.

XXXIV. CALCIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Lime, &c.

XXXV. BARIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Baryta, &c.

XXXVI. STRONTIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Strontia, &c.

6. EARTHY METALS.

XXXVII. MAGNESIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Magnesia, &c.

XXXVIII. YTTRIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Yttria, &c.

XXXIX. ALUMINUM. (a) Properties. (b) Process for obtaining.

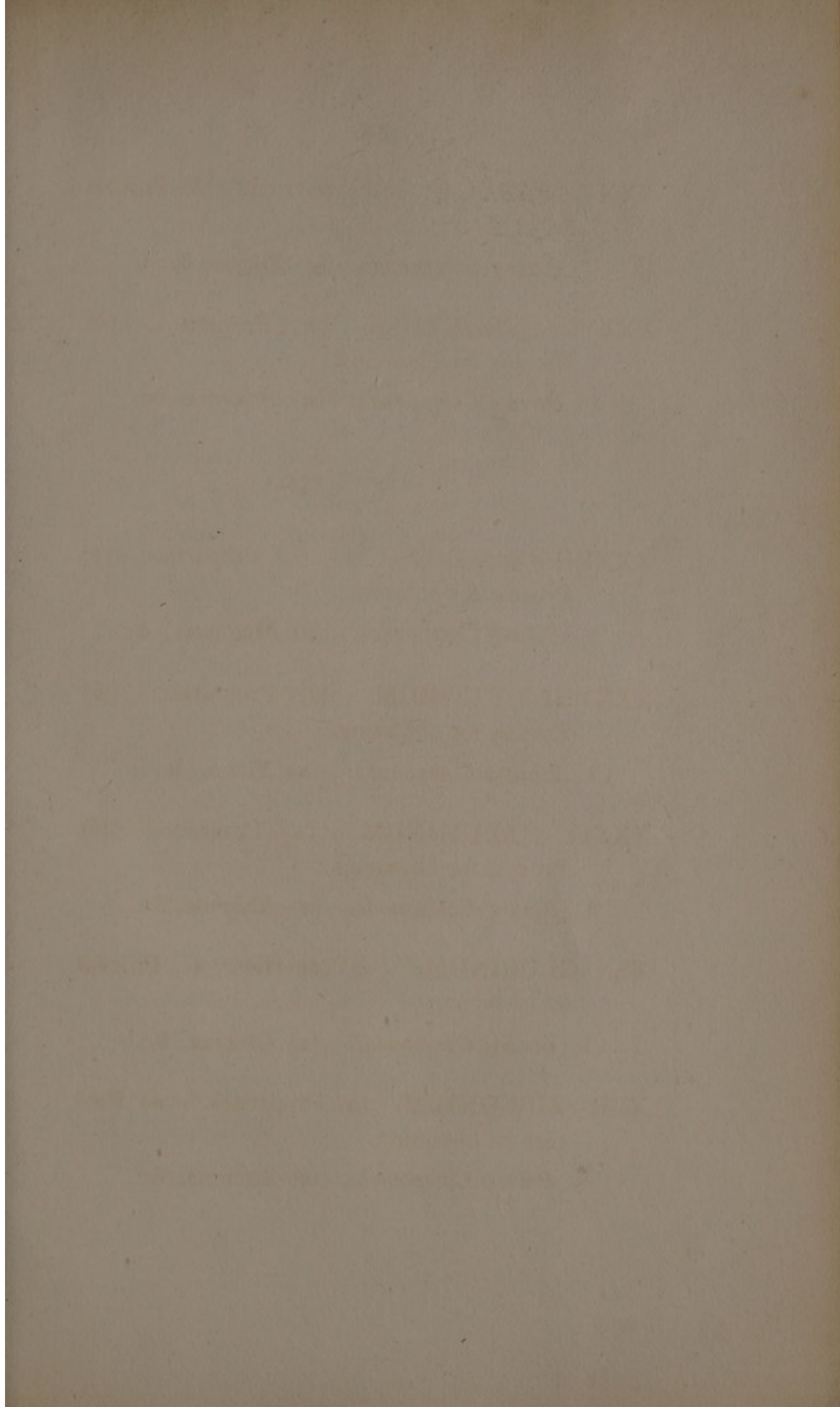
1. *Binary Compounds.* (a) Alumina, &c.

XL. GLUCINUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Glucina, &c.

XLI. ZIRCONIUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Zirconia, &c.



XXXV. BARIUM (a) Preparation (b) Properties
for analysis

1. Heavy Carbonate (c) Barium, etc.

XXXVI. STRONTIUM (a) Preparation (b)
Properties for analysis

1. Heavy Carbonate (c) Strontium, etc.

2. Heavy Nitrate

XXXVII. MAGNESIUM (a) Preparation (b)
Properties for analysis

1. Heavy Carbonate (c) Magnesium, etc.

XXXVIII. LITHIUM (a) Preparation (b)
Properties for analysis

1. Heavy Carbonate (c) Lithium, etc.

XXXIX. ALUMINUM (a) Preparation (b)
Properties for analysis

1. Heavy Carbonate (c) Aluminum, etc.

XL. ZINC (a) Preparation (b) Properties
for analysis

1. Heavy Carbonate (c) Zinc, etc.

XLI. ARSENIC (a) Preparation (b) Properties
for analysis

1. Heavy Carbonate (c) Arsenic, etc.

THE THEORY OF THE HYPERBOLIC

by H. POINCARÉ

Translated by J. H. CONWAY

I. GENERAL REMARKS ON THE THEORY

1. The theory of the hyperbolic is a branch of the theory of the differential equations.

- (a) The theory of the hyperbolic is a branch of the theory of the differential equations.
- (b) The theory of the hyperbolic is a branch of the theory of the differential equations.
- (c) The theory of the hyperbolic is a branch of the theory of the differential equations.

2. The theory of the hyperbolic is a branch of the theory of the differential equations.

3. The theory of the hyperbolic is a branch of the theory of the differential equations.

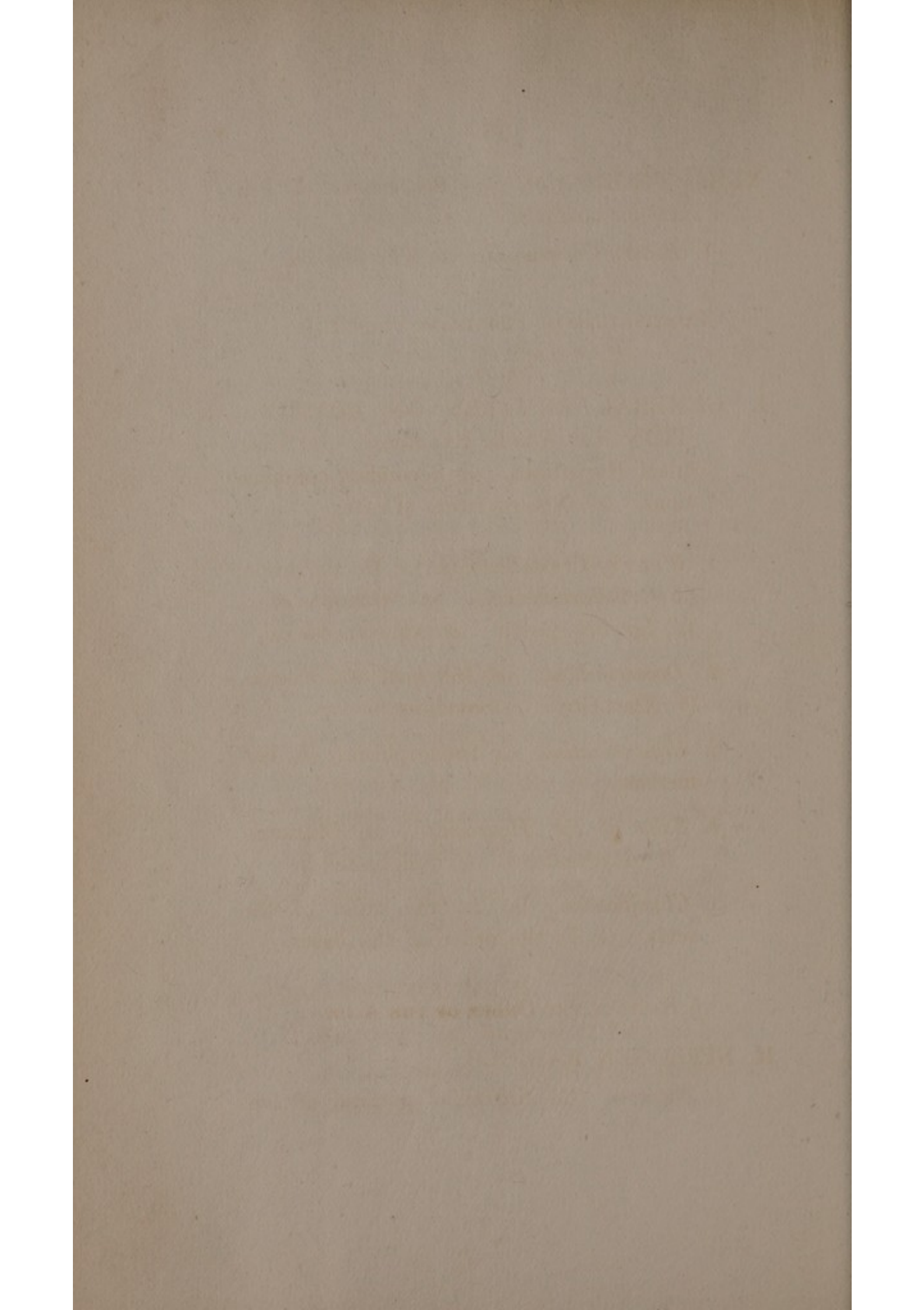
4. The theory of the hyperbolic is a branch of the theory of the differential equations.

5. The theory of the hyperbolic is a branch of the theory of the differential equations.

6. The theory of the hyperbolic is a branch of the theory of the differential equations.

II. THE THEORY OF THE HYPERBOLIC

1. The theory of the hyperbolic is a branch of the theory of the differential equations.



XLII. THORINUM. (a) Properties. (b) Process for obtaining.

1. *Binary Compounds.* (a) Thorina, &c.

COMBINATIONS OF PROXIMATE PRINCIPLES.

SALTS.

I. GENERAL REMARKS ON COMBINATION. (a) Atomic Hypothesis. (b) Electrical Hypothesis. (c) Secondary combinations. (d) Nomenclature of salts.

1. *Water of Crystallization.* (a) Decrepitation. (b) Efflorescence. (c) Deliquescence. (d) Igneous fusion. (e) Aqueous fusion.

2. *Decomposition.* (a) Influence of Cohesion. (b) Elasticity. (c) Solubility.

3. *Crystallization.* (a) Isomorphism. (b) Isomerism.

4. *Salts of the Hydracids.* (a) Muriates. (b) Hydriodates. (c) Sulpho-salts.

5. *Classification.* (a) In the order of the acids. (b) In the order of the bases.

§ SALTS IN THE ORDER OF THE ACIDS.

II. NITROGEN RADICLE.

1. *Nitrates.* (a) Nitrate of potassa, (Pulvis

fulminans, Gunpowder.) (b) Nitrate of soda. (c) Nitrate of ammonia. (d) Nitrates of baryta, strontia, lime, &c. (e) Nitrates of copper, lead, mercury, silver, &c. (f.) Tests.

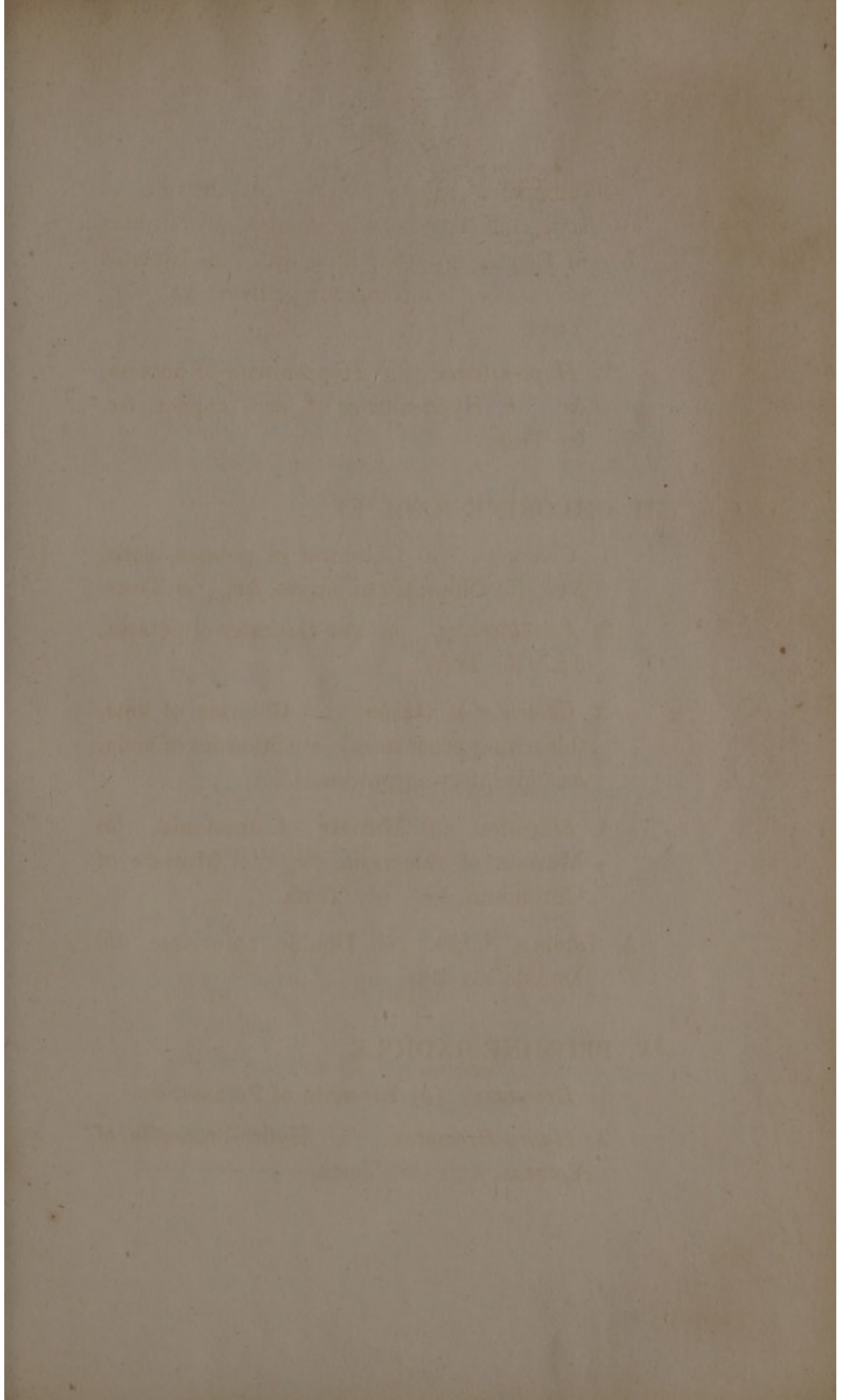
2. *Hypo-nitrites*. (a) Hypo-nitrite of potassa, &c. (b) Hypo-nitrites of lead, copper, &c. (c) Tests.

III. CHLORINE RADICLE,

1. *Chlorates*. (a) Chlorates of potassa, soda, &c. (b) Chlorates of baryta, &c. (c) Tests.
 2. *Per-chlorates*. (a) Per-chlorates of potassa, &c. (b) Tests.
 3. *Chlorides of Oxides*. (a) Chloride of lime, (bleaching processes). (b) Chlorides of soda, &c. (disinfecting processes.)
 4. *Muriates*. (a) Muriate of ammonia. (b) Muriate of magnesia, &c. (c) Muriate of Chromium, &c. (d) Tests.
- A. DOUBLE SALTS. (a) Double chlorides. (b) Double oxi-salts.

IV. BROMINE RADICLE.

1. *Bromates*. (a) Bromate of Potassa, &c.
2. *Hydro-Bromates*. (a) Hydro-bromates of Potassa, &c. (b) Tests.



Alkalies, *Alkalies*. (a) Nitrate of soda. (b) Nitrate of ammonia. (c) Nitrate of potash, *Alkalies*, *Alkalies*, *Alkalies*, *Alkalies*. (d) Nitrate of copper, lead, mercury, silver, *Alkalies*. (e) Tests.

1. *Hypo-nitrites*. (a) Hypo-nitrite of potash, *Alkalies*. (b) Hypo-nitrite of lead, copper, *Alkalies*. (c) Tests.

III. CHLORINE RADICALS.

1. *Chlorides*. (a) Chloride of potash, soda, *Alkalies*. (b) Chloride of barium, *Alkalies*. (c) Tests.

2. *Hydro-chlorides*. (a) Hydro-chloride of ammonia, *Alkalies*. (b) Tests.

3. *Chlorides of Oxide*. (a) Chloride of lead, *Alkalies*, *Alkalies*, *Alkalies*. (b) Chloride of soda, *Alkalies*, *Alkalies*, *Alkalies*. (c) Tests.

4. *Muriates*. (a) Muriate of ammonia. (b) Muriate of magnesia, *Alkalies*. (c) Muriate of Chromium, *Alkalies*. (d) Tests.

5. *Double Salts*. (a) Double chloride. (b) Double sulfate.

IV. BROMINE RADICALS.

1. *Bromides*. (a) Bromide of Potash, *Alkalies*.

2. *Hydro-bromides*. (a) Hydro-bromide of Potash, *Alkalies*. (b) Tests.

V. IODINE RADICLE.

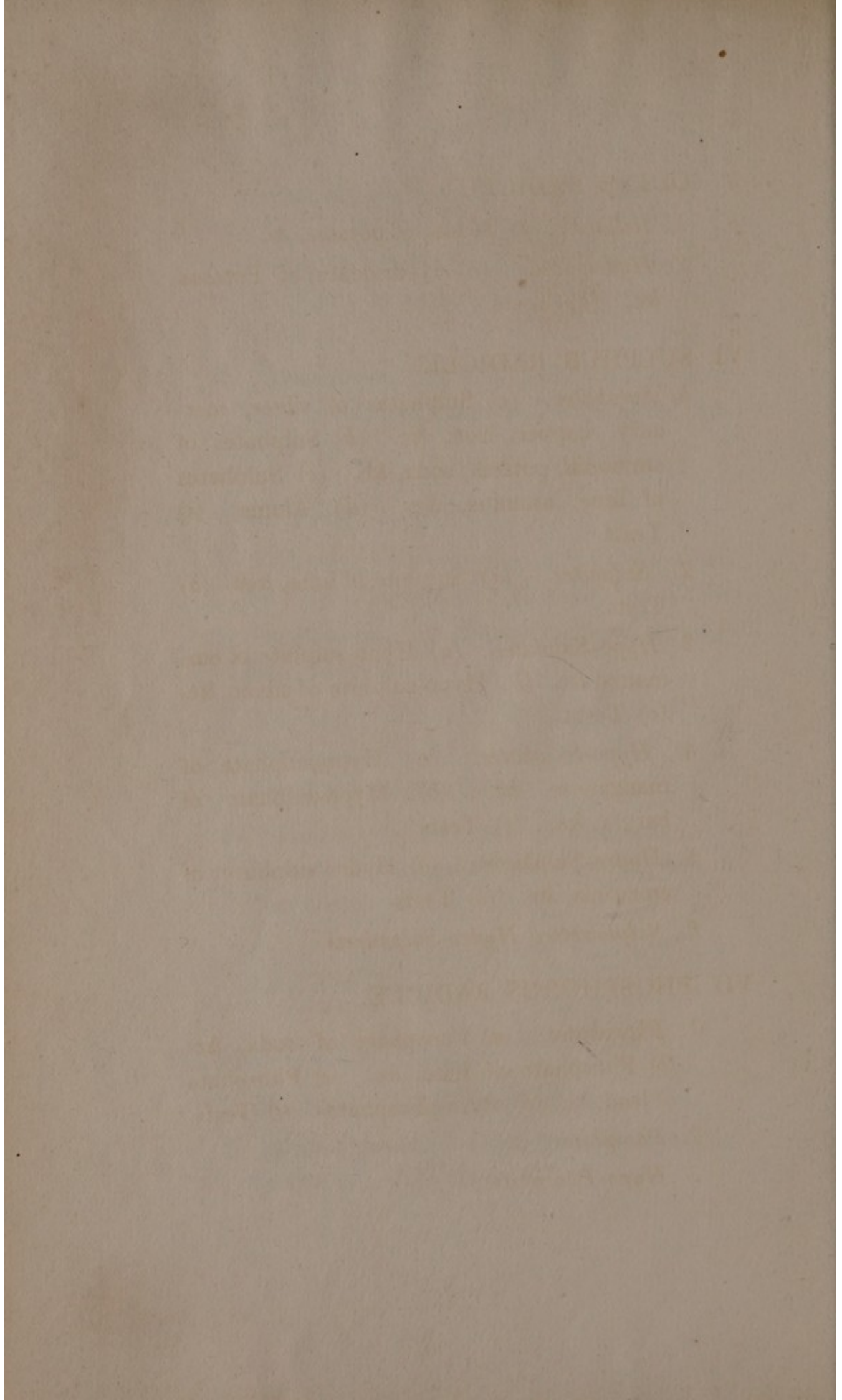
1. Iodides. (a) Iodide of potassium, &c.
2. Iodates. (a) Iodate of Potassium, &c. (b) Tests.

VI. SULPHUR RADICLE.

1. Sulphates. (a) Sulphates of silver, mercury, copper, iron, &c. (b) Sulphates of ammonia, potassa, soda, &c. (c) Sulphates of lime, alumina, &c. (d) Alums. (e) Tests.
2. Sulphites. (a) Sulphite of lime, &c. (b) Tests.
3. Hypo-Sulphites. (a) Hypo-sulphite of ammonia, &c. (b) Hypo-sulphite of silver, &c. (c) Tests.
4. Hypo-Sulphates. (a) Hypo-sulphate of ammonia, &c. (b) Hypo-sulphate of baryta, &c. (c) Tests.
5. Hydro-Sulphates. (a) Hydro-sulphates of arsenious, &c. (b) Tests.
6. Sulphurated Hydro-Sulphurates.

VII. PHOSPHORUS RADICLE.

1. Phosphates. (a) Phosphate of soda, &c. (b) Phosphate of lime, &c. (c) Phosphate of lead, &c. (d) Pyro-phosphates. (e) Tests.
2. Phosphites.
3. Hypo-Phosphites.



V. IODINE RADICLE.

1. *Iodates*. (a) Iodate of potassa, &c.
2. *Hydriodates*. (a) Hydriodate of Potassa, &c. (b) Tests.

VI. SULPHUR RADICLE.

1. *Sulphates*. (a) Sulphates of silver, mercury, copper, iron, &c. (b) Sulphates of ammonia, potassa, soda, &c. (c) Sulphates of lime, alumina, &c. (d) Alums. (e) Tests.
2. *Sulphites*. (a) Sulphite of lime, &c. (b) Tests.
3. *Hypo-Sulphites*. (a) Hypo-sulphite of ammonia, &c. (b) Hypo-sulphite of silver, &c. (c) Tests.
4. *Hypo-Sulphates*. (a) Hypo-sulphate of manganese, &c. (b) Hypo-sulphate of baryta, &c. (c) Tests.
5. *Hydro-Sulphurets*. (a) Hydro-sulphuret of ammonia, &c. (b) Tests.
6. *Sulphuretted Hydro-Sulphurets*.

VII. PHOSPHORUS RADICLE.

1. *Phosphates*, (a) Phosphate of soda, &c. (b) Phosphate of lime, &c. (c) Phosphate of lead, &c. (d) Pyro-phosphates. (e) Tests.
2. *Phosphites*.
3. *Hypo-Phosphites*.

VIII. CARBON RADICLE.

1. *Carbonates*. (a) Carbonates of ammonia, potassa, soda, &c. (b) Carbonates of baryta, &c. (c) Carbonates of iron, copper, lead, &c. (d) Tests.
2. *Oxalates*. (a) Tests.

IX. BORON RADICLE.

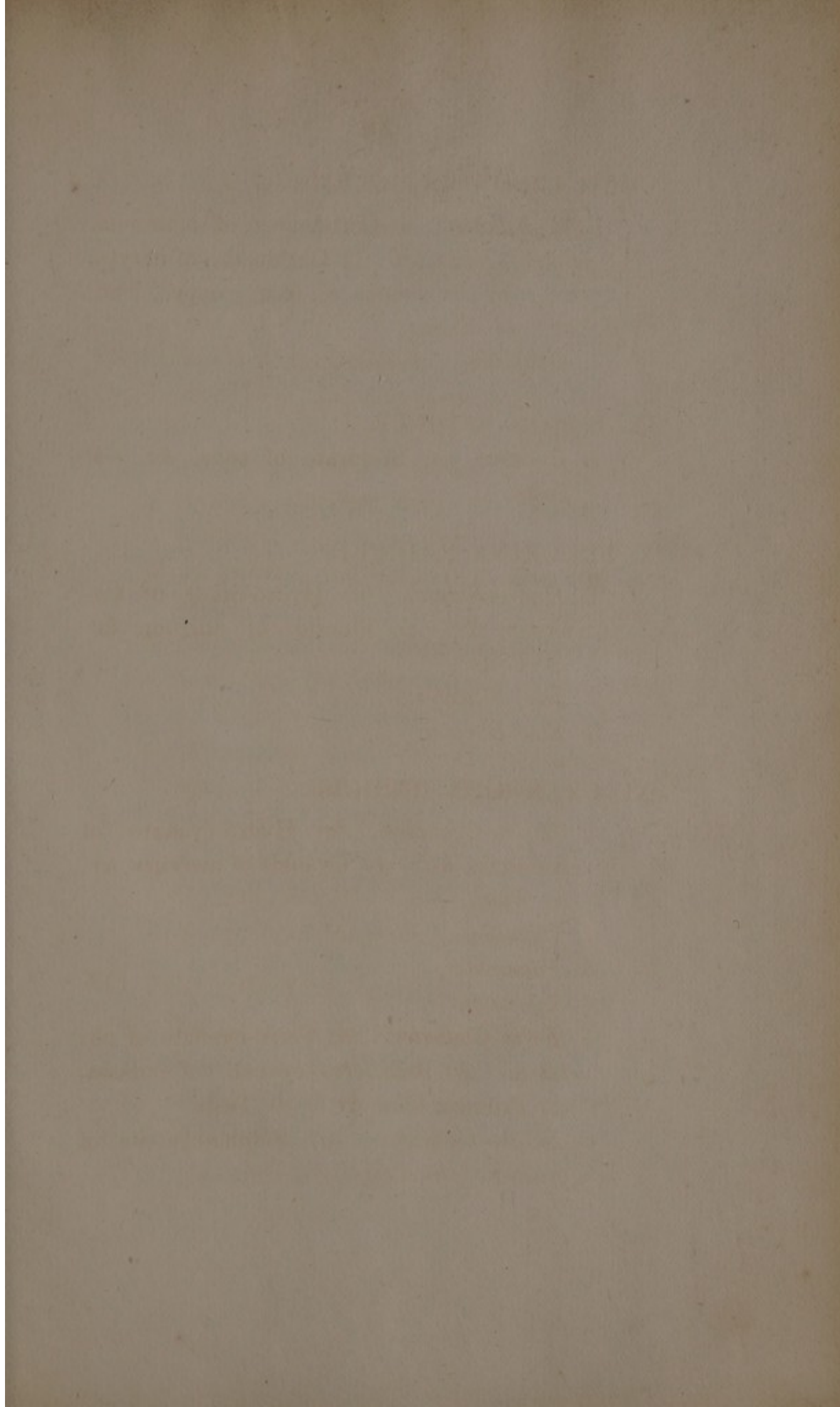
1. *Borates*. (a) Bi-borate of soda, &c. (b) Tests.

X. FLUORINE RADICLE.

1. *Hydro-Fluates*. (a) Hydro-fluate of ammonia, &c. (b) Fluoride of calcium, &c. (c) Tests.
2. *Fluo-Silicates*.
3. *Fluo-Borates*.

XI. CYANOGEN RADICLE.

1. *Hydro-Cyanates*. (a) Hydro-cyanates of ammonia, &c. (b) Cyanide of mercury, &c. (c) Tests.
2. *Cyanites*.
3. *Fulminates*.
4. *Cyanates*.
5. *Ferro-Cyanates*. (a) Ferro-cyanate of potassa. (b) Red ferro-cyanate of potassa. (c) Prussian blue, &c. (d) Tests.
6. *Sulpho-Cyanates*. (a) Sulpho-cyanate of potassa. (b) Tests.



VIII. CARBON RADICLE.

1. Carbonates. (a) Carbonates of ammonia, potash, soda, &c. (b) Carbonates of baryta, &c. (c) Carbonates of iron, copper, lead, &c. (d) Tests.
2. *Acidities*. (a) Tests.

IX. BORON RADICLE.

1. Borates. (a) Borates of soda, &c. (b) Tests.

X. FLUORINE RADICLE.

1. Hydro-Fluorates. (a) Hydro-fluorates of ammonia, &c. (b) Fluorides of calcium, &c. (c) Tests.
2. Fluor Silicates.
3. Fluor Borates.

XI. CYANIDE RADICLE.

1. Hydro-Cyanides. (a) Hydro-cyanides of ammonia, &c. (b) Cyanide of mercury, &c. (c) Tests.
2. Cyanides.
3. Fulminates.
4. Cyanates.
5. Ferro-Cyanates. (a) Ferrocyanates of potash, &c. (b) Red ferrocyanide of calcium. (c) Prussian blue, &c. (d) Tests.
6. Sulpho-Cyanides. (a) Sulpho-cyanides of potash, &c. (b) Tests.

XII. METALLIC RADICALS

1. Arsenioid. (a) Arsenioid. (b) Test.
2. Chromioid. (a) Test.
3. Arsenioid. (a) Arsenioid. (b) Test.

3. Salt is the basis of this group.

XIII. SUBDIVISION OF SALTS

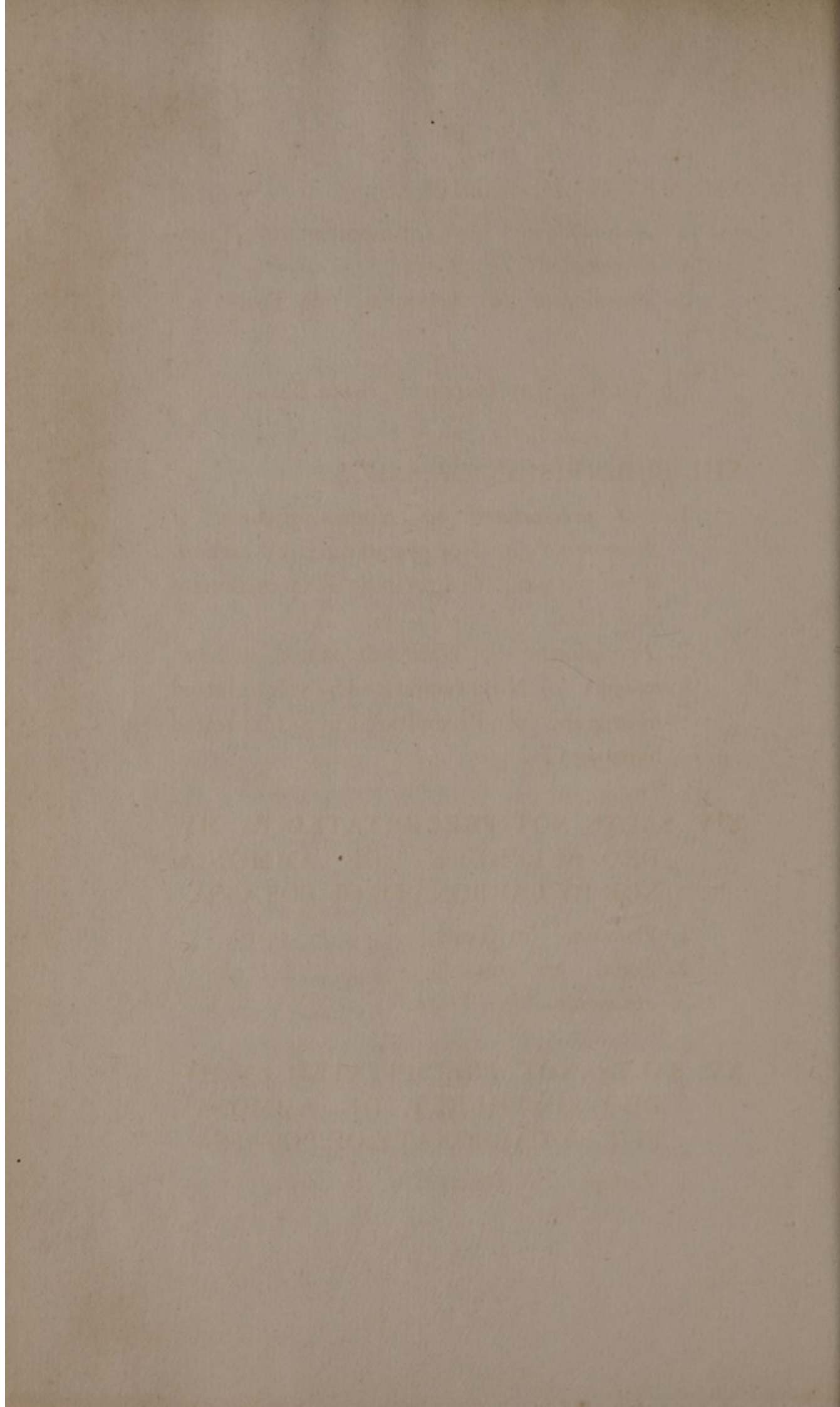
1. Not precipitated by Hydro-sulphate of Ammonia. (a) Not precipitated by carbonate of potash. (b) Precipitated by carbonate of potash.
2. Precipitated by Hydro-sulphate of Ammonia. (a) Not precipitated by sulphuretted hydrogen. (b) Precipitated by sulphuretted hydrogen.

XIV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA NOR BY CARBONATE OF POTASH.

1. Potash. (a) Test.
2. Soda. (a) Test.
3. Ammonia. (a) Test.

XV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA, BUT BY CARBONATE OF POTASH.

1. Test. (a) Test.



XII. METALLIC RADICLES.

1. *Antimoniates*. (a) Antimonites. (b) Tests.
2. *Chromates*. (a) Tests.
3. *Arseniates*. (a) Arsenites. (b) Tests.

§ SALTS IN THE ORDER OF THEIR BASES.

XIII. SUBDIVISION OF SALTS.

1. *Not precipitated by Hydro-Sulphuret of Ammonia*. (a) Not precipitated by carbonate of potassa. (b) Precipitated by carbonate of potassa.
2. *Precipitated by Hydro-Sulphuret of Ammonia*. (a) Not precipitated by sulphuretted hydrogen. (b) Precipitated by sulphuretted hydrogen.

XIV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA, NOR BY CARBONATE OF POTASSA.

1. *Potassa*. (a) Tests.
2. *Soda*. (a) Tests.
3. *Ammonia*. (a) Tests.

XV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA, BUT BY CARBONATE OF POTASSA.

1. *Lithia*. (a) Tests.

2. *Baryta.* (a) Tests.
3. *Strontia.* (a) Tests.
4. *Lime.* (a) Tests.
5. *Magnesia.* (a) Tests.

XVI. SALTS PRECIPITATED BY SULPHURET OF AMMONIA, BUT NOT BY SULPHURETTED HYDROGEN.

1. *Alumina.* (a) Tests.
2. *Manganese.* (a) Tests.
3. *Zinc.* (a) Tests.
4. *Iron.* (a) Tests.
5. *Cobalt.* (a) Tests.
6. *Nickel.* (a) Tests.

XVII. SALTS PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA AND BY SULPHURETTED HYDROGEN.

1. *Chromium.* (a) Tests.
2. *Tin.* (a) Tests.
3. *Cadmium.* (a) Tests.
4. *Antimony.* (a) Tests.
5. *Bismuth.* (a) Tests.
6. *Lead.* (a) Tests.
7. *Copper.* (a) Tests.
8. *Mercury.* (a) Tests.
9. *Silver.* (a) Tests.
10. *Platinum.* (a) Tests.
11. *Gold.* (a) Tests.



2. *Baryta.* (a) Tests.
3. *Strontia.* (a) Tests.
4. *Caia.* (a) Tests.
5. *Magnesia.* (a) Tests.

XVI. SALTS PRECIPITATED BY SULPHURET OF AMMONIA, BUT NOT BY SULPHURETTED HYDROGEN.

1. *Alumina.* (a) Tests.
2. *Manganese.* (a) Tests.
3. *Zinc.* (a) Tests.
4. *Iron.* (a) Tests.
5. *Cobalt.* (a) Tests.
6. *Nickel.* (a) Tests.

XVII. SALTS PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA AND BY SULPHURETTED HYDROGEN.

1. *Chromium.* (a) Tests.
2. *Tin.* (a) Tests.
3. *Cadmium.* (a) Tests.
4. *Antimony.* (a) Tests.
5. *Bismuth.* (a) Tests.
6. *Lead.* (a) Tests.
7. *Copper.* (a) Tests.
8. *Mercury.* (a) Tests.
9. *Silver.* (a) Tests.
10. *Platinum.* (a) Tests.
11. *Gold.* (a) Tests.

XVIII. *PLICATES* in *Chem. & Phys.*

A. *Analysis of Minerals*

Part II.

THE PRINCIPLES, TECHNIQUES, AND PRODUCTS OF CHEMICAL ANALYSIS

I. INTRODUCTORY REMARKS. (a) The course of life. (b) Generation. (c) The ducts. (d) Death. (e) Dehydration. (f) Minerals.

II. ANALYSIS. (a) Descriptive. (b) Method of Gas Analysis and Titration. (c) Method of Dr. Priest. (d) Laboratory. (e) Analytical chemistry.

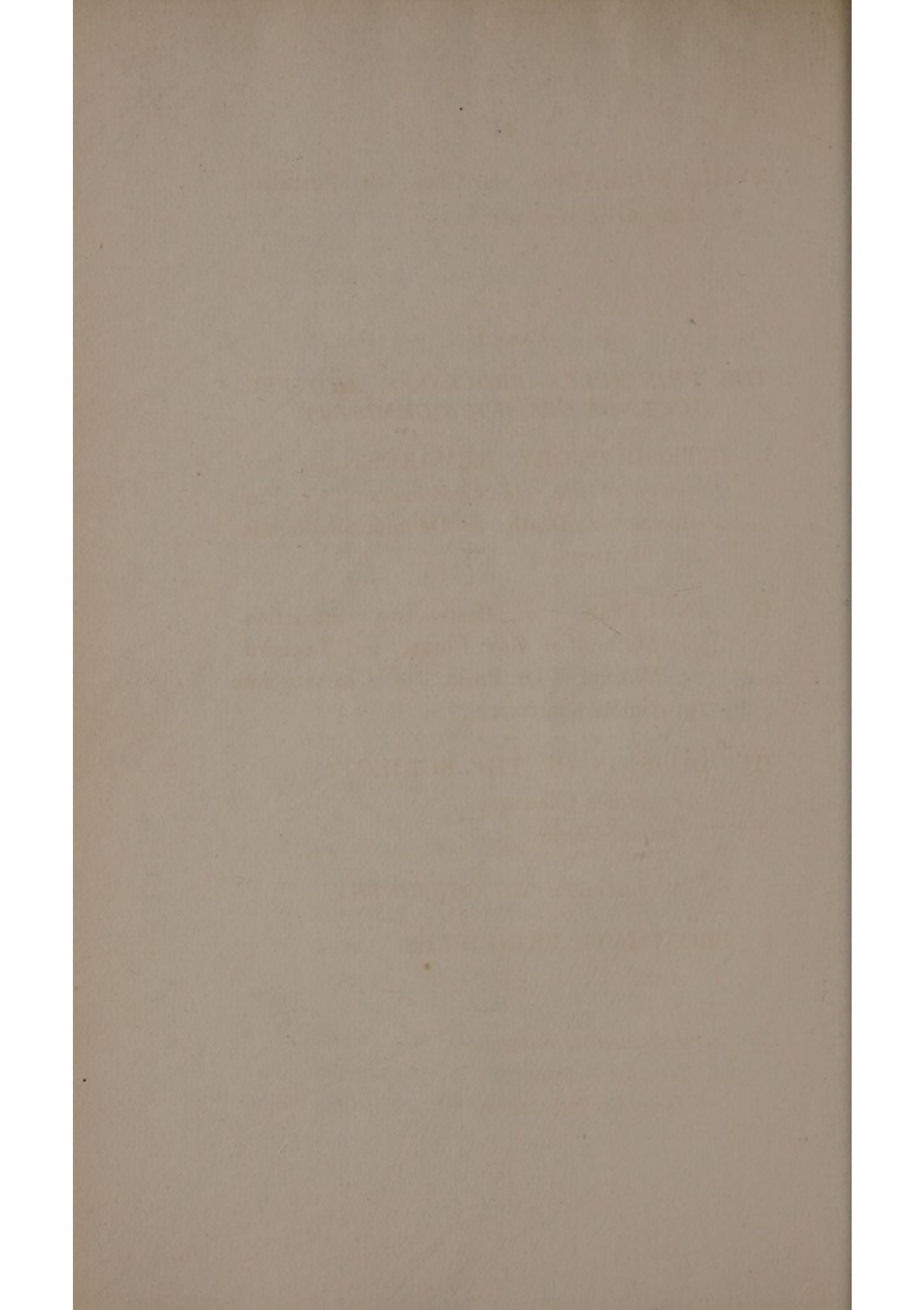
III. DIVISION OF THE SUBJECT

1. *Vegetable Chemistry*
2. *Animal Chemistry*

1. *VEGETABLE CHEMISTRY*

I. PROXIMATE PRINCIPLES

1. *Acids*
2. *Alkalies*
3. *Ignominable Substances*
4. *Neutral Substances*
5. *Indigestible Substances*



XVIII. SILICATES. (a) Glass. (b) Porcelain.

A. *Analysis of Minerals.*

PART II.

THE PRINCIPLES, PROCESSES, AND PRODUCTS OF ORGANIC CHEMISTRY.

I. INTRODUCTORY REMARKS. (a) Processes of life. (b) Organization. (c) Products. (d) Death. (e) Definite compounds. (f) Mixtures.

II. ANALYSIS. (a) Destructive distillation. (b) Method of Gay Lussac and Thenard. (c) Method of Dr. Prout. (d) Ultimate and proximate analyses.

III. DIVISION OF THE SUBJECT.

1. *Vegetable Chemistry.*
2. *Animal Chemistry.*

§ VEGETABLE CHEMISTRY.

I. PROXIMATE PRINCIPLES.

1. *Acids.*
2. *Bases.*
3. *Inflammable Substances.*
4. *Neutral Substances.*
5. *Indefinite Substances.*

II. ASHES.

1. VEGETABLE ACIDS.

III. ACETIC ACIDS. (a) Vinegar. (b) Pyro-ligneous acid. (c) Crystallizable acid. (d) Analysis. (e) Lampic acid. (f) Lactic acid.

1. *Acetates*. (a) Acetate of ammonia, &c. (b) Acetate of baryta, &c. (c) Acetate of copper, &c. (d) Tests.

IV. OXALIC ACID. (a) Preparation. (b) Properties. (c) Analysis.

1. *Oxalates*. (a) Oxalate of ammonia, &c. (b) Oxalate of lime, &c. (c) Tests.
2. *Oxalamide*.

V. TARTARIC ACID. (a) Preparation. (b) Properties. (c) Analysis. (d) Pyro-tartaric acid.

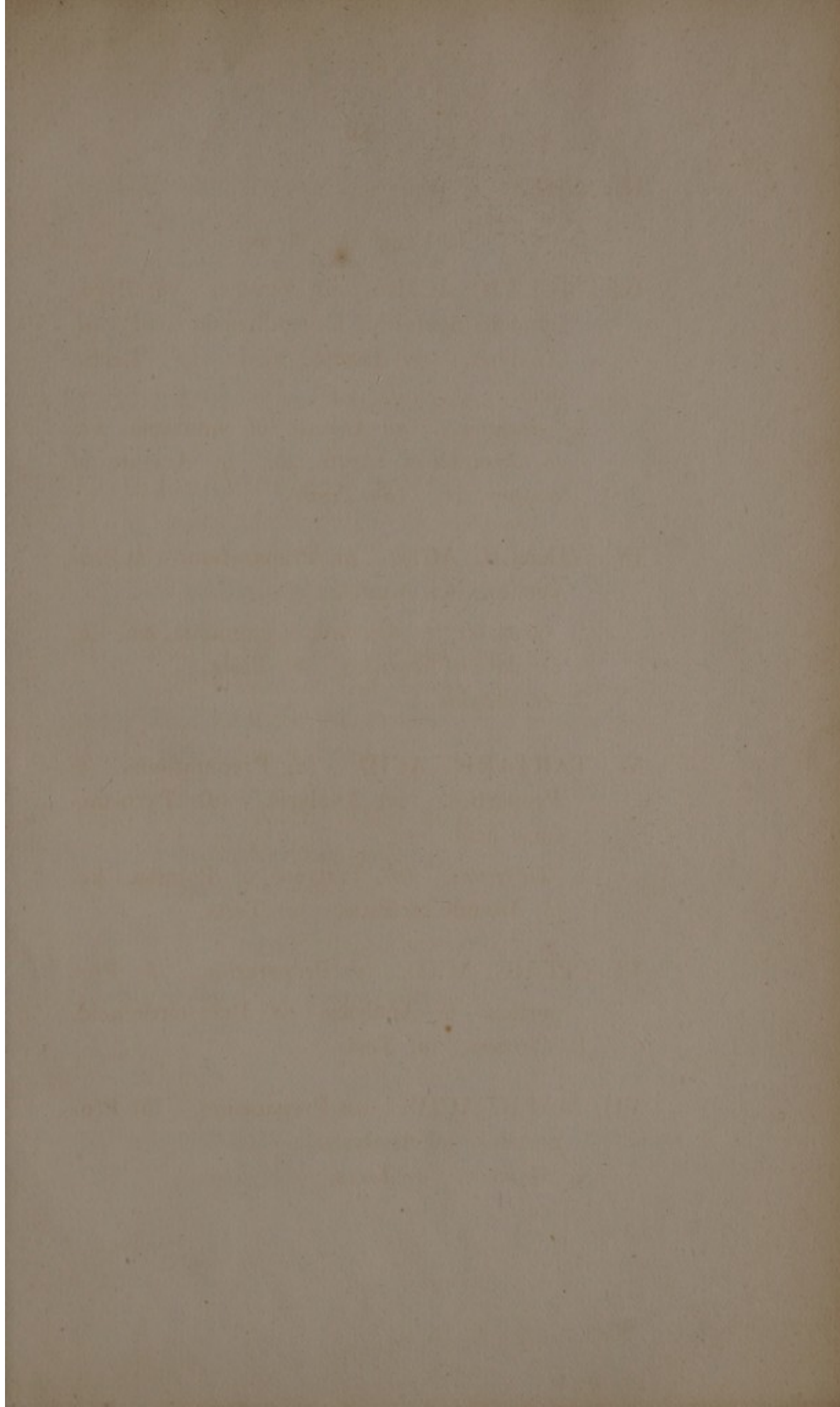
1. *Tartrates*. (a) Tartrate of Potassa, &c. (b) Double tartrates. (c) Tests.

VI. CITRIC ACID. (a) Preparation. (b) Properties. (c) Analysis. (d) Pyro-citric acid.

1. *Citrates*. (a) Tests.

VII. MALIC ACID. (a) Preparation. (b) Properties. (c) Analysis.

1. *Malates*. (a) Tests.



III. ACIDS.

1. Vinegaric Acid.

III. ACETIC ACIDS. (a) Vinegar. (b) Pure Acetic acid. (c) Crystallizable acid. (d) Analysis. (e) Lactic acid. (f) Tartaric acid.

1. Sources. (a) Acetates of ammonia, &c. (b) Acetates of baryta, &c. (c) Acetate of copper, &c. (d) Tests.

IV. OXALIC ACID. (a) Preparation. (b) Properties. (c) Analysis.

1. Oxides. (a) Double oxides. (b) Oxides of barium, &c. (c) Tests.
2. Acetates.

V. TARTARIC ACID. (a) Preparation. (b) Properties. (c) Analysis. (d) Pyrotartaric acid.

1. Tartarates. (a) Tartarates of Potassa, &c. (b) Double tartarates. (c) Tests.

VI. CITRIC ACID. (a) Preparation. (b) Properties. (c) Analysis. (d) Pyrocitric acid. (e) Citrates. (f) Tests.

VII. MALIC ACID. (a) Preparation. (b) Properties. (c) Analysis.

1. Malates. (a) Tests.

VIII. GLUCIC ACID. (a) Preparation. (b) Properties.
(c) Analysis.

1. Glucose. (a) Tests.

IX. TARTARIC ACID. (a) Preparation. (b) Properties.
(c) Tests.

1. Potassium Tartrate.

X. PECTIC ACID. (a) Preparation. (b) Properties.

1. Pectin. (a) Tests.

XI. SEBACIC ACID. (a) Preparation. (b) Properties.

1. Sebacic Acid. (a) Tests.

XII. BENZOIC ACID. (a) Preparation. (b) Properties.

1. Benzoic Acid. (a) Tests.

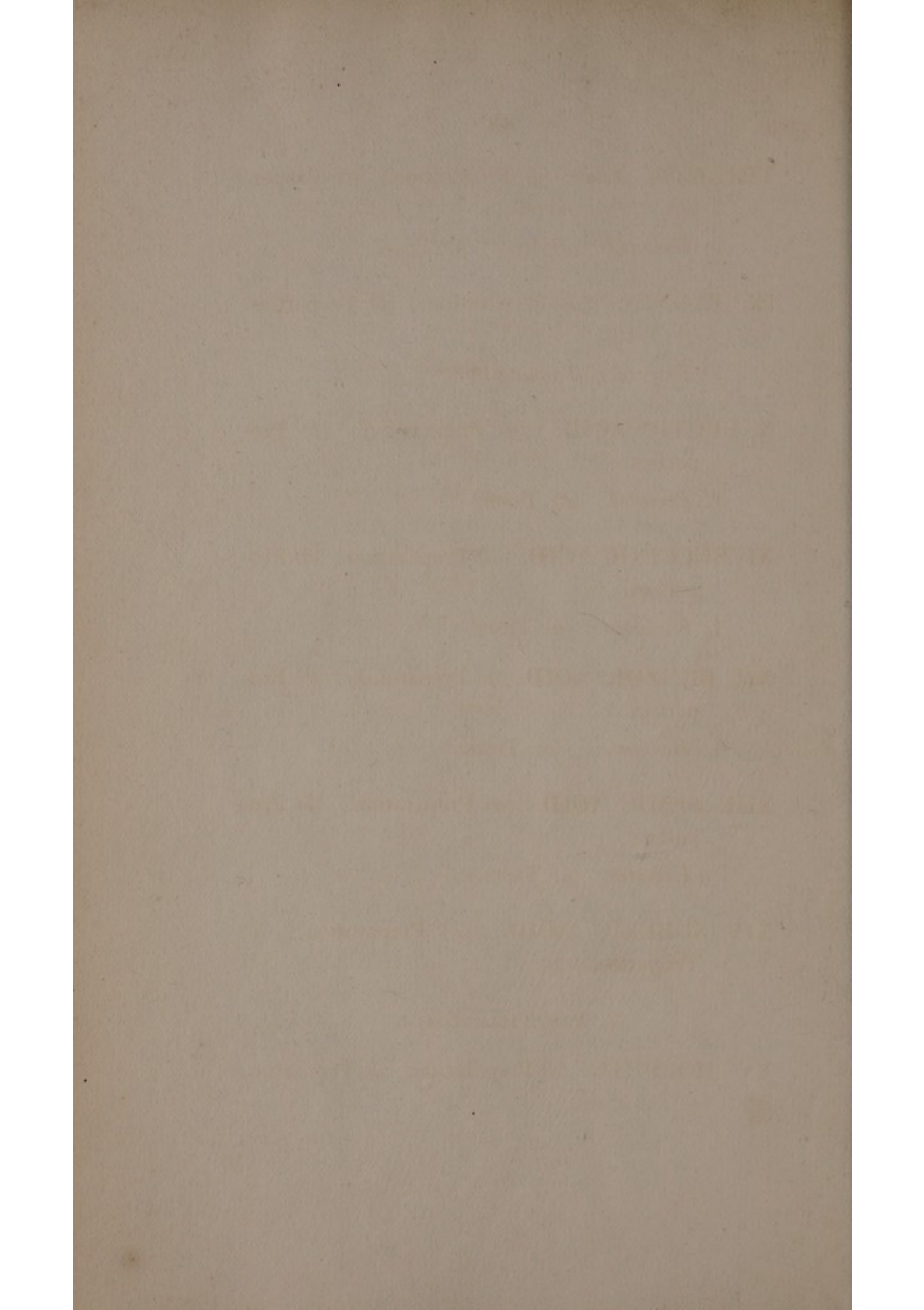
XIII. ULMIC ACID. (a) Preparation. (b) Properties.

1. Ulmic Acid. (a) Tests.

XIV. SUBERIC ACID. (a) Preparation. (b) Properties.

2. Vinylic Acids.

XV. MUCIC ACID. (a) Preparation. (b) Properties.
(c) Analysis.



VIII. *Gallic Acid*. (a) Preparation. (b) Properties. (c) Analysis.

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1. *Process of Tanning*.

X. PECTIC ACID. (a) Preparation. (b) Properties.

1. *Pectates*. (a) Tests.

XI. SUCCINIC ACID. (a) Preparation. (b) Properties.

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XII. BENZOIC ACID. (a) Preparation. (b) Properties.

1. *Benzoates*. (a) Tests.

XIII. ULMIC ACID. (a) Preparation. (b) Properties.

1. *Ulmates*. (a) Tests.

XIV. SUBERIC ACID. (a) Preparation. (b) Properties.

2. VEGETABLE BASES.

XV. MORPHIA. (a) Preparation. (b) Properties. (c) Analysis.

1. *Narcotine.*
2. *Meconic Acid.*
3. *Salts of Morphia.* (a) Tests.

XVI. STRYCHNIA. (a) Preparation. (b) Properties. (c) Analysis.

1. *Salts of Strychnia.*

XVII. VERATRIA. (a) Preparation. (b) Properties. (c) Analysis.

1. *Salts of Veratria.*

XVIII. BRUCIA. (a) Preparation. (b) Properties. (c) Analysis.

1. *Salts of Brucia.*

XIX. CINCHONIA. (a) Preparation. (b) Properties. (c) Analysis.

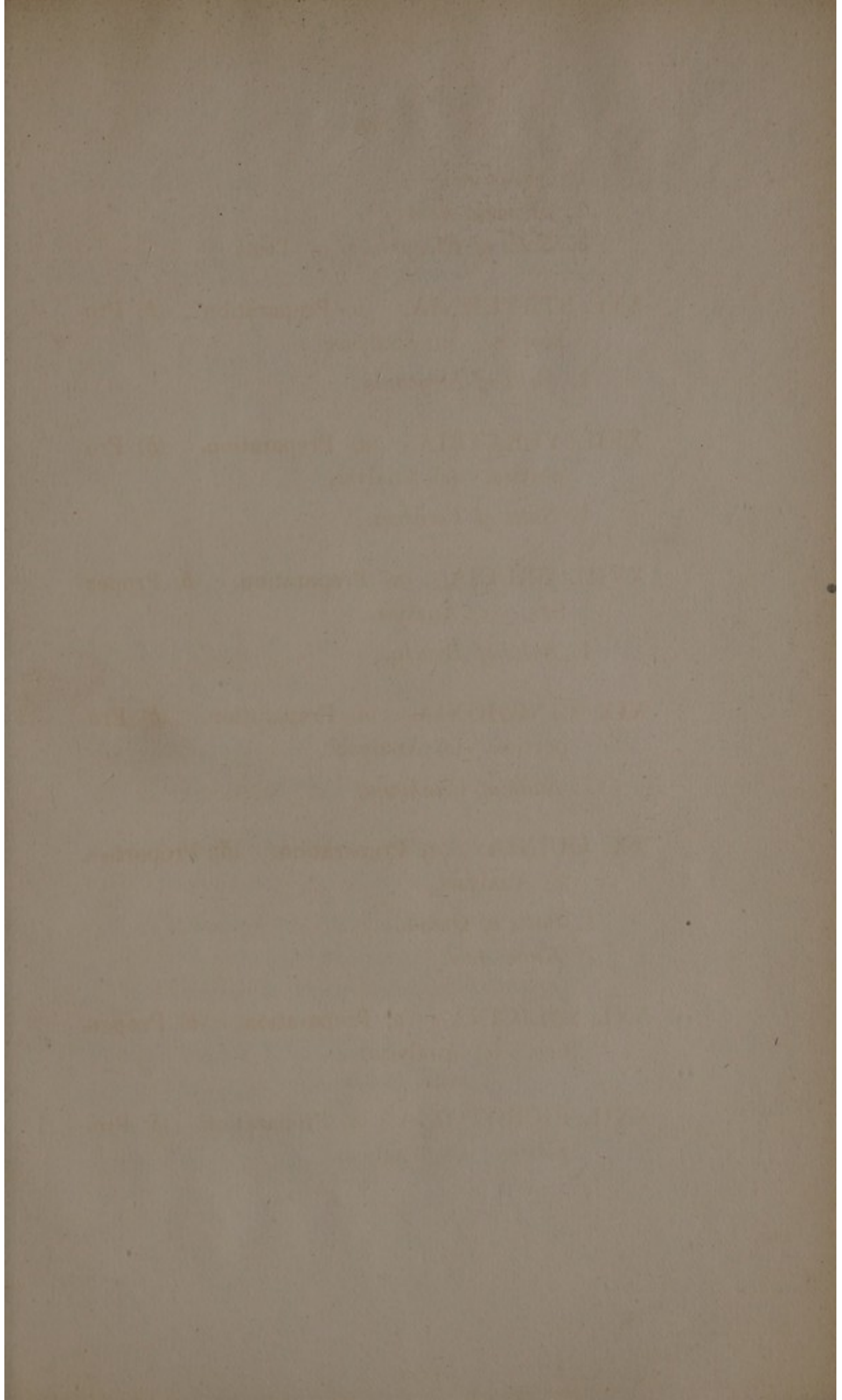
1. *Salts of Cinchonia.*

XX. QUINIA. (a) Preparation. (b) Properties. (c) Analysis.

1. *Salts of Quinia.*
2. *Kinic Acid.*

XXI. SALICINA. (a) Preparation. (b) Properties. (c) Analysis.

XXII. PICROTOXIA. (a) Preparation. (b) Properties. (c) Analysis.



1. *Preparation.*
2. *Properties.*
3. *Analysis.*

XVI. *STYRACIA.* (a) *Preparation.* (b) *Properties.* (c) *Analysis.*
 1. *Salt of Styria.*

XVII. *VERATRIA.* (a) *Preparation.* (b) *Properties.* (c) *Analysis.*
 1. *Salt of Veratrum.*

XVIII. *BRUCIA.* (a) *Preparation.* (b) *Properties.* (c) *Analysis.*
 1. *Salt of Brucia.*

XIX. *CINCHONA.* (a) *Preparation.* (b) *Properties.* (c) *Analysis.*
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XXI. *SALICINA.* (a) *Preparation.* (b) *Properties.* (c) *Analysis.*

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XXIII. EMULSION. (a) Preparation. (b) Properties, &c.

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XXV. DELPHINIA. (a) Preparation. (b) Properties, &c.

XXVI. CAPEA. (a) Preparation. (b) Properties, &c.

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XXVIII. WAX. (a) Sources. (b) Uses. (c) Analysis.

XXIX. CAOUTCHOUC. (a) Preparation. (b) Properties. (c) Analysis.

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1. Saponification. (a) Materials. (b) Process.

XXX. VOLATILE OILS.

1. Volatile. (a) Sources of ingredients. (b) Uses.

2. Aromatic. (a) Sources. (b) Properties, &c.

THE HISTORY OF THE

REIGN OF

CHARLES THE FIRST

BY

JOHN BURNET

OF

THE UNIVERSITY OF OXFORD

IN TWO VOLUMES

LONDON

Printed by J. Streater, at the Sign of the Gun, in St. Dunstons Church-yard, 1679.

XXIII. EMETINA. (a) Preparation. (b) Properties, &c.

XXIV. PIPERINA. (a) Preparation. (b) Properties, &c.

XXV. DELPHINIA. (a) Preparation. (b) Properties, &c.

XXVI. CAFEA. (a) Preparation. (b) Properties, &c.

3. INFLAMMABLE PRINCIPLES.

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(c) Drying oils. (d) Analysis.

XXVIII. WAX. (a) Bees' wax. (b) Vegetable wax. (c) Analysis.

XXIX. CAOUTCHOUC. (a) Preparation. (b) Properties. (c) Analysis.

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1. *Salts of the Fatty Acids.* (a) Soaps.

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XXXII. ALCOHOL. (a) Preparation. (b) Properties. (c) Analysis.

1. *Alcohates.*

XXXIII. ETHER. (a) Preparation. (b) Properties. (c) Analysis.

1. *Sulpho-vinic Acid.* (a) Oil of wine. (b) Sulpho-vinates.

2. *Hydro - acid Ethers.* (a) Muriatic ether. Hydriodic ether.

3. *Vegetable Acid Ethers.* (a) Nitric ether. (b) Acetic ether. (c) Oxalic ether.

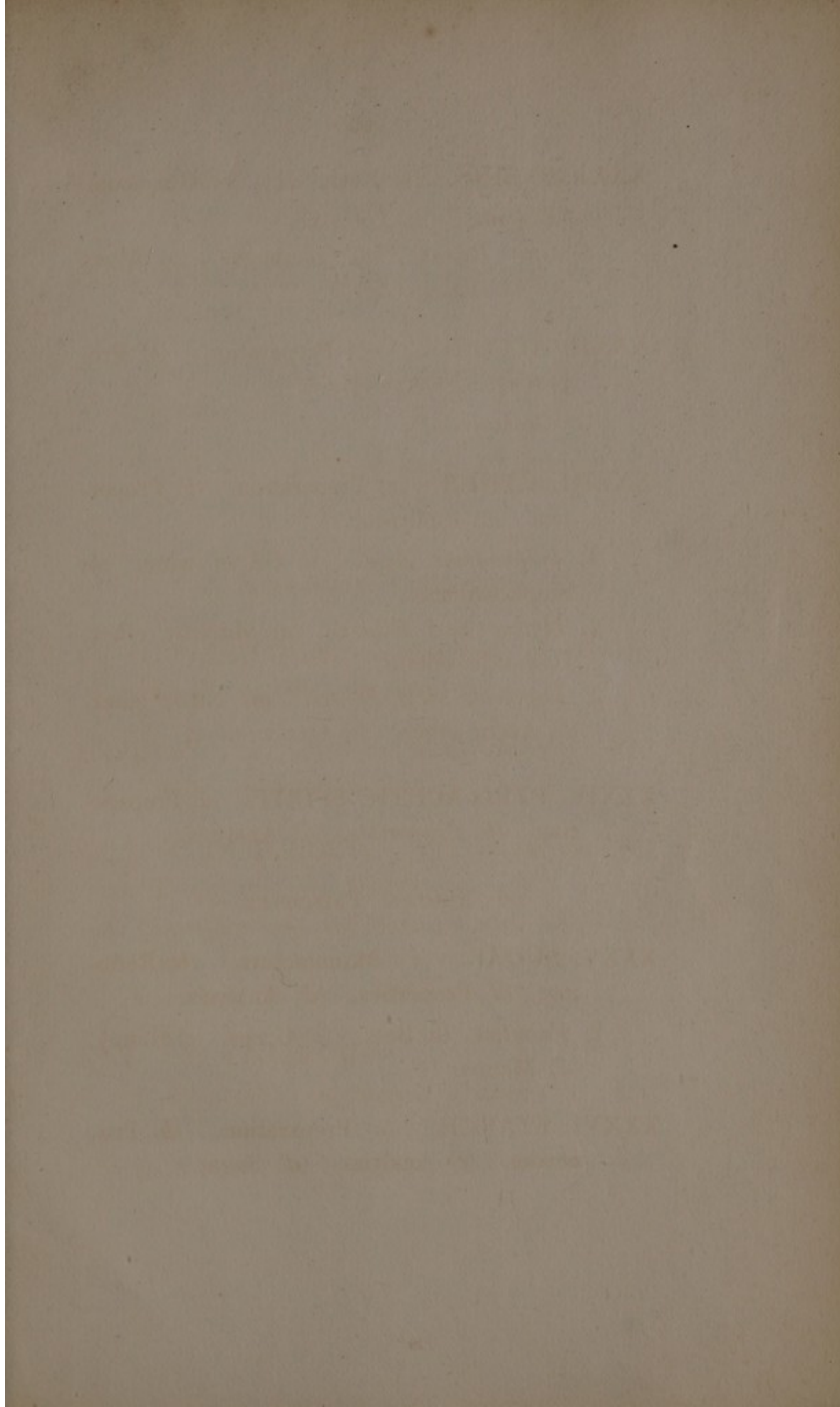
XXXIV. PYRO-ACETIC SPIRIT. (a) Preparation. (b) Properties. (c) Analysis.

4. NEUTRAL PRINCIPLES.

XXXV. SUGAR. (a) Manufacture. (b) Refining. (c) Properties. (d) Analysis.

1. *Varieties.* (a) Beet. (b) Grape. (c) Honey. (d) Manna.

XXXVI. STARCH. (a) Preparation. (b) Properties. (c) Analysis. (d) Sugar.



1. *Journal of the Proceedings of the*
General Assembly of the

General Assembly of the
General Assembly of the

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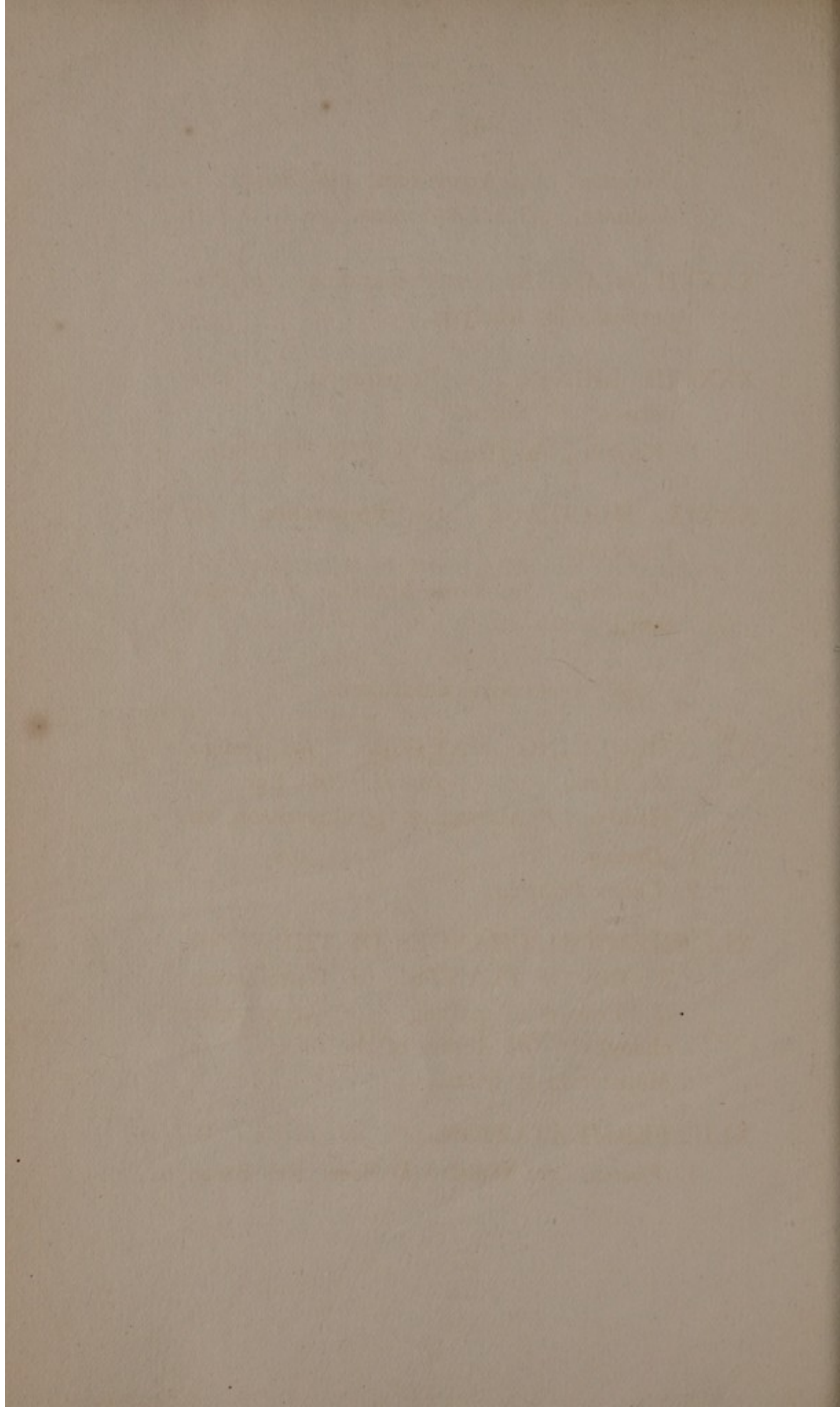
7. *Journal of the Proceedings of the*
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9. *Journal of the Proceedings of the*
General Assembly of the

10. *Journal of the Proceedings of the*
General Assembly of the

11. *Journal of the Proceedings of the*
General Assembly of the



- 1 *Varieties.* (a) Arrow root. (b) Sago. (c) Tapioca. (d) Iceland moss.

XXXVII. GLUTEN. (a) Preparation. (b) Properties. (c) Analysis.

XXXVIII. LIGNIN. (a) Preparation. (b) Properties. (c) Sugar.

1. *Varieties.* (a) Hemp. (b) Flax. (c) Cotton.

XXXIX. MUCILAGE. (a) Preparation. (b) Properties.

1. *Varieties.* (a) Gum Arabic. (b) Tragacanth, &c.

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2. *Calico Printing.*

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ANIMAL CHEMISTRY.

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2. *Animal Acids.*

3. *Animal Fats.*

1. SUBSTANCES NEITHER ACID NOR OLEAGINOUS.

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(c) Tests. (d) Analysis.

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VI. OSMAZOME. (a) Preparation. (b) Properties.

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Analysis. (d) Artificial.



THEORY OF
ELECTRICITY

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- 2. Electric Field
- 3. Electric Intensity

2. ELECTROSTATIC POTENTIAL AND CAPACITANCE

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- 2. Potential of a Point Charge
- 3. Potential of a System of Charges

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- 2. Capacitance of a Parallel Plate Condenser
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5. ELECTROSTATIC ENERGY

- 1. Definition of Energy
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THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

REPORT OF THE

COMMISSIONERS OF THE

BOARD OF TRUSTEES

FOR THE YEAR 1891

CHICAGO

1892

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

REPORT OF THE

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1892

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PHYSICS DEPARTMENT

REPORT OF THE

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VIII. ANIMAL SUGAR. (a) Of Milk. (b) Of Diabetes. (c) Of glue.

2. ANIMAL ACIDS.

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2. *Fluid.*

1. SOLID PARTS OF ANIMALS.

I. BONES. (a) Shells. (b) Crusts, &c.

II. HORNS. (a) Nails. (b) Scales. (c) Hair, &c.

III. MUSCLES. (a) Tendons. (b) Skin, &c.

2. FLUID PARTS OF ANIMALS.

IV. CHYLE. (a) Chyme. (b) Gastric juice.

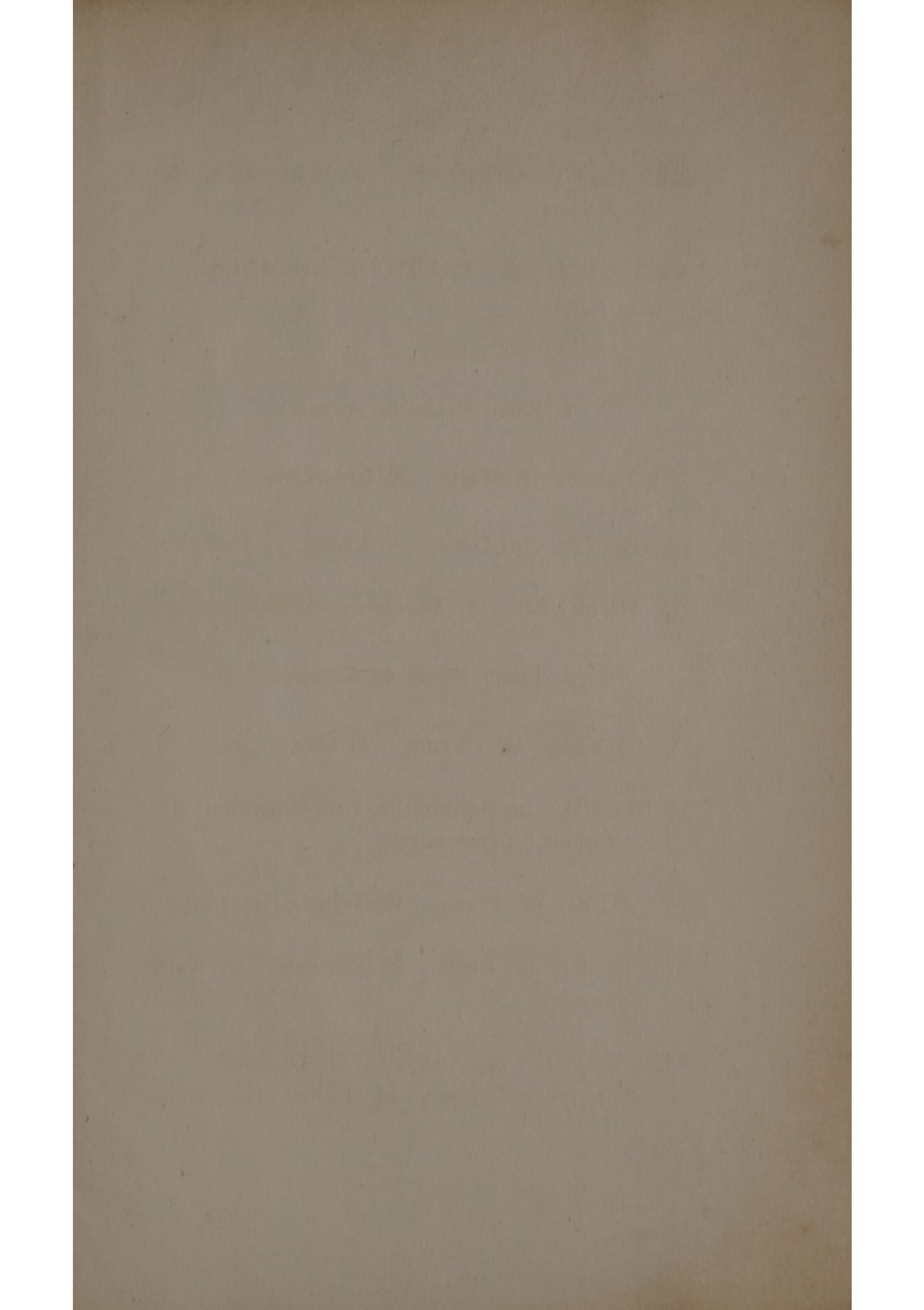
V. BLOOD. (a) Serum. (b) Crassamentum. (c) Colour. (d) Analysis.

VI. MILK. (a) Cream. (b) Whey. (c) Curd.

VII. BILE. (a) Resin. (c) Picromel. (c) Gallstones.

VIII. URINE. (a) Analysis. (b) Diseased.

1. *Urinary Calculi.* (a) Lithic acid series.



XXI. GASTROINTESTINAL SYSTEM
Digestion

XXII. COMPLEX PARTS OF ANIMALS

I. Bones

II. Horns

I. Solid Parts of Animals

I. BONES. (a) Bones. (b) Cartilage.

II. HORNS. (a) Horns. (b) Bones. (c) Horns.

III. TENDONS. (a) Tendons. (b) Skin.

I. Fluid Parts of Animals

II. CHOLE. (a) Chole. (b) Chole.

V. BLOOD. (a) Blood. (b) Coagulation. (c) Color. (d) Analysis.

VI. MILK. (a) Milk. (b) Milk. (c) Milk.

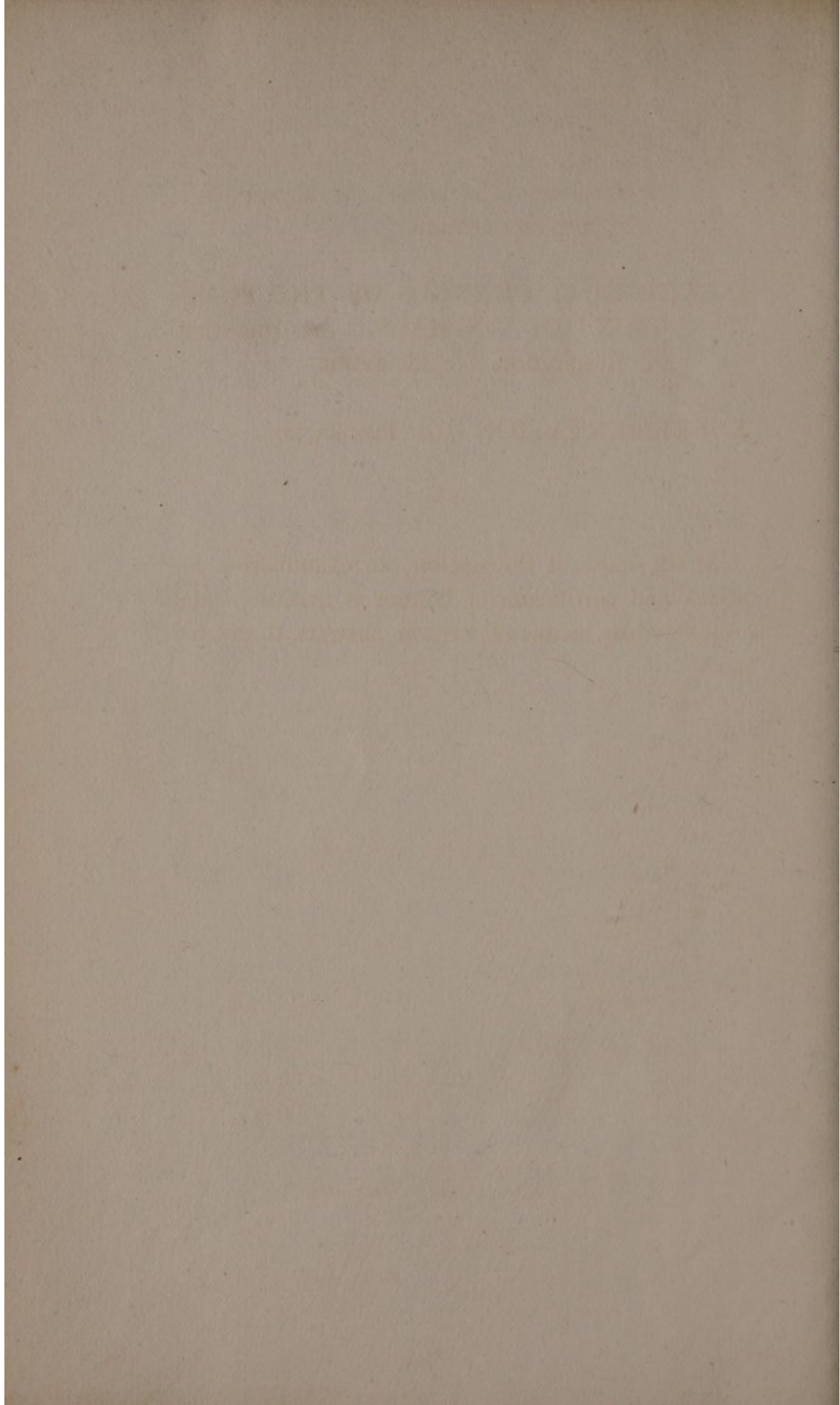
VII. URINE. (a) Urine. (b) Urine. (c) Urine.

VIII. URINE. (a) Urine. (b) Urine. (c) Urine.

THE UNIVERSITY OF CHICAGO
DEPARTMENT OF CHEMISTRY

IV. CHEMICAL PROPERTIES OF POLYMER
FORMED IN THE PRESENCE OF
A. TERMINATION OF POLYMERIZATION

At the close of the reaction, an examination of the
product and analysis of the polymer is required and
the polymer is found to be a mixture of
polymers of various degrees of polymerization
and structure.



(*b*) Oxalate of lime series. (*c*) Cystic oxide and phosphate of lime.

IX. CHEMICAL CHANGES OF THE FUNCTIONS OF ANIMALS. (*a*) Digestion. (*b*) Respiration. (*c*) Secretion.

X. FERMENTATION. (*a*) Putrefaction.

At the close of the session, an examination for prizes and certificates of honour is instituted and conducted by means of written answers to printed questions.

FINIS,

(b) Oxidate of lime series. (c) Oxidate of lime
and phosphate of lime.

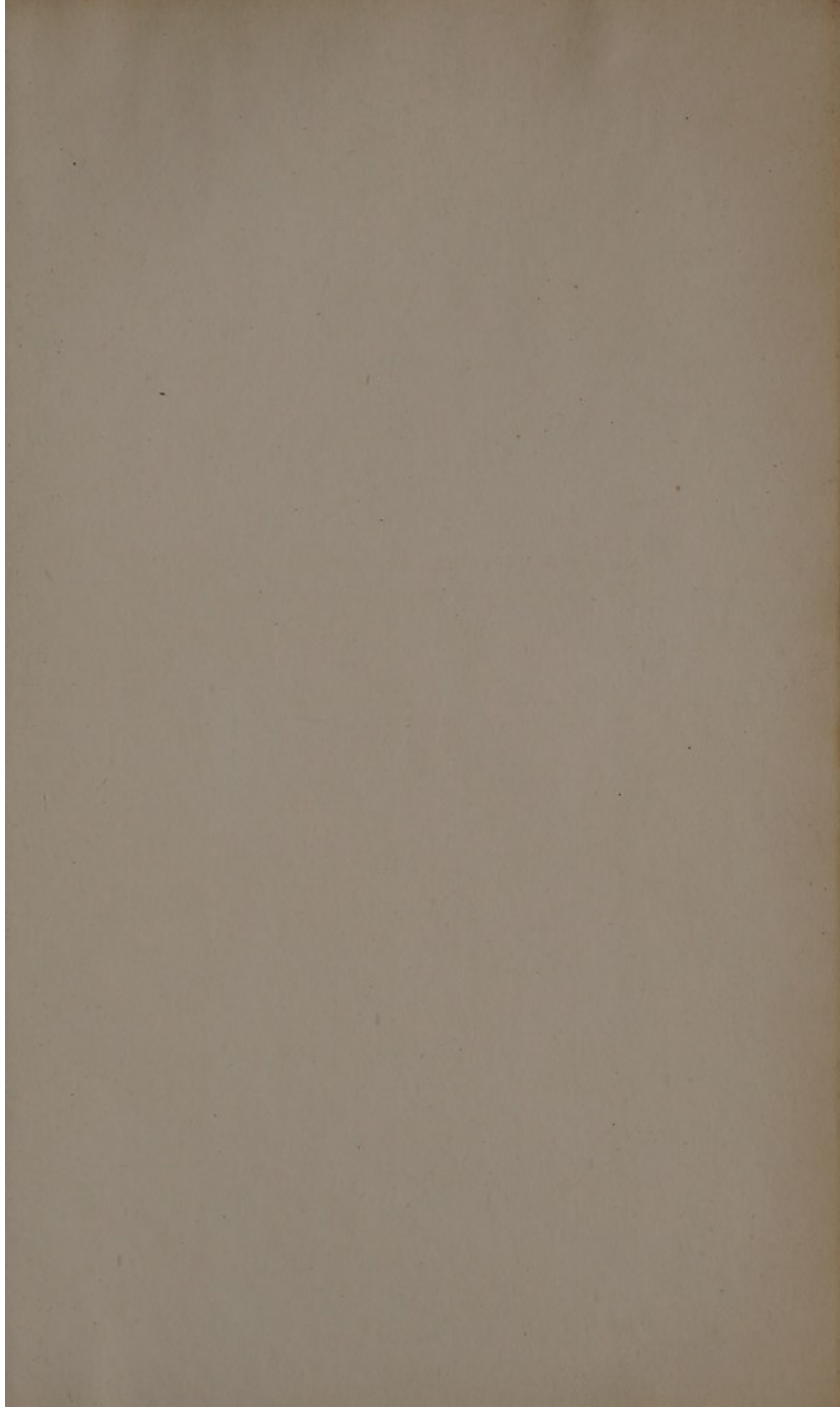
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(b) Respiration. (c) Secretion.

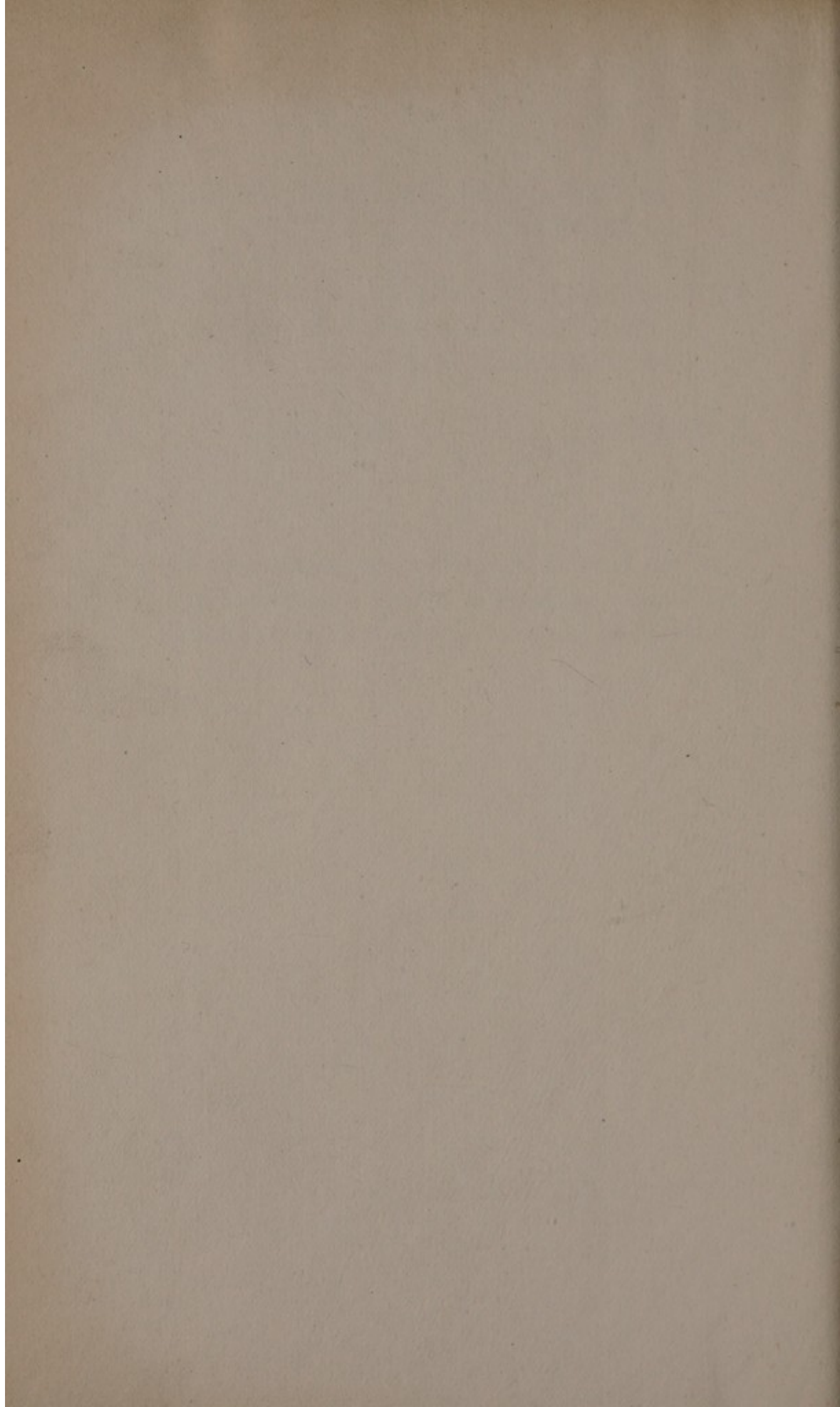
X. FERMENTATION. (a) Putrefaction.

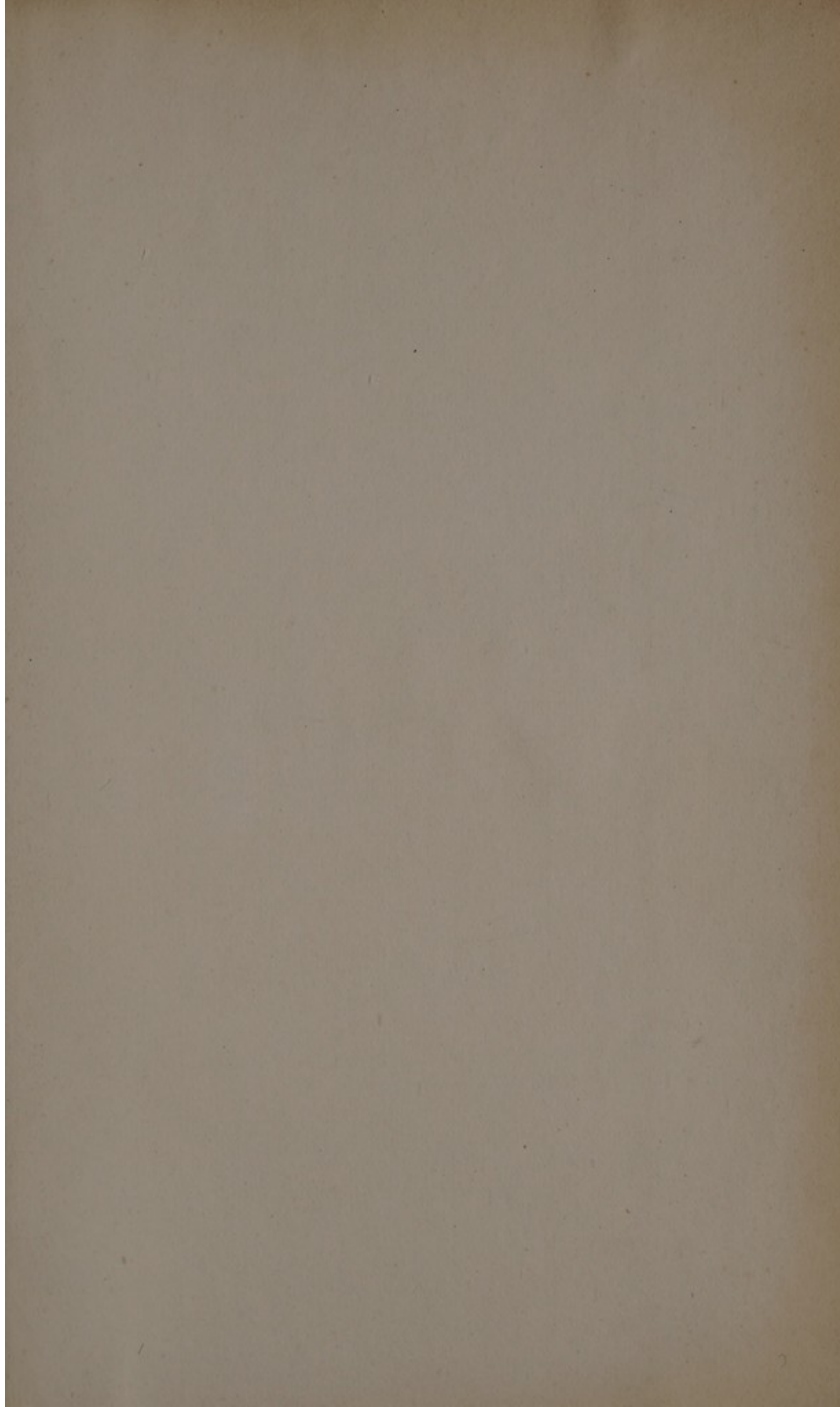
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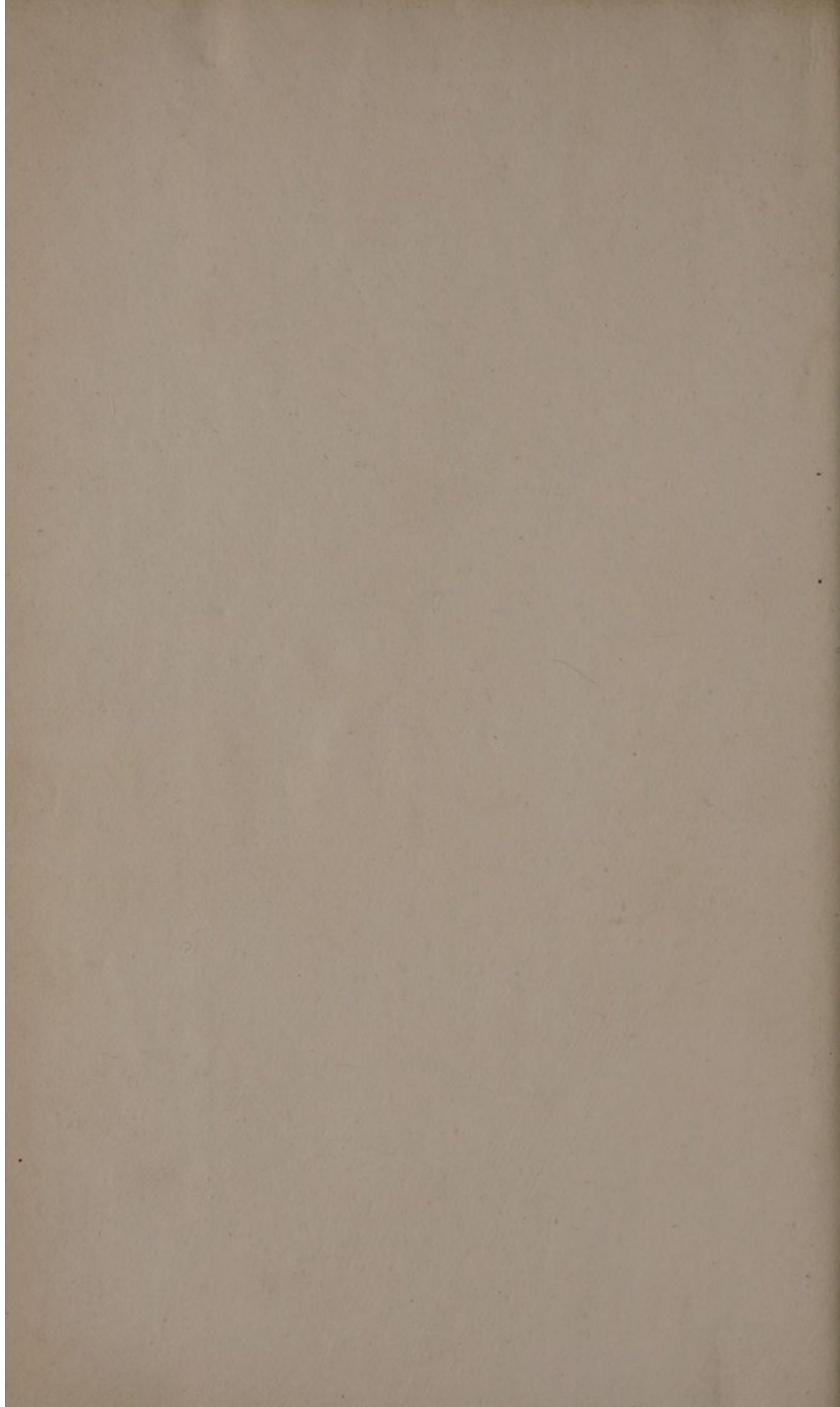
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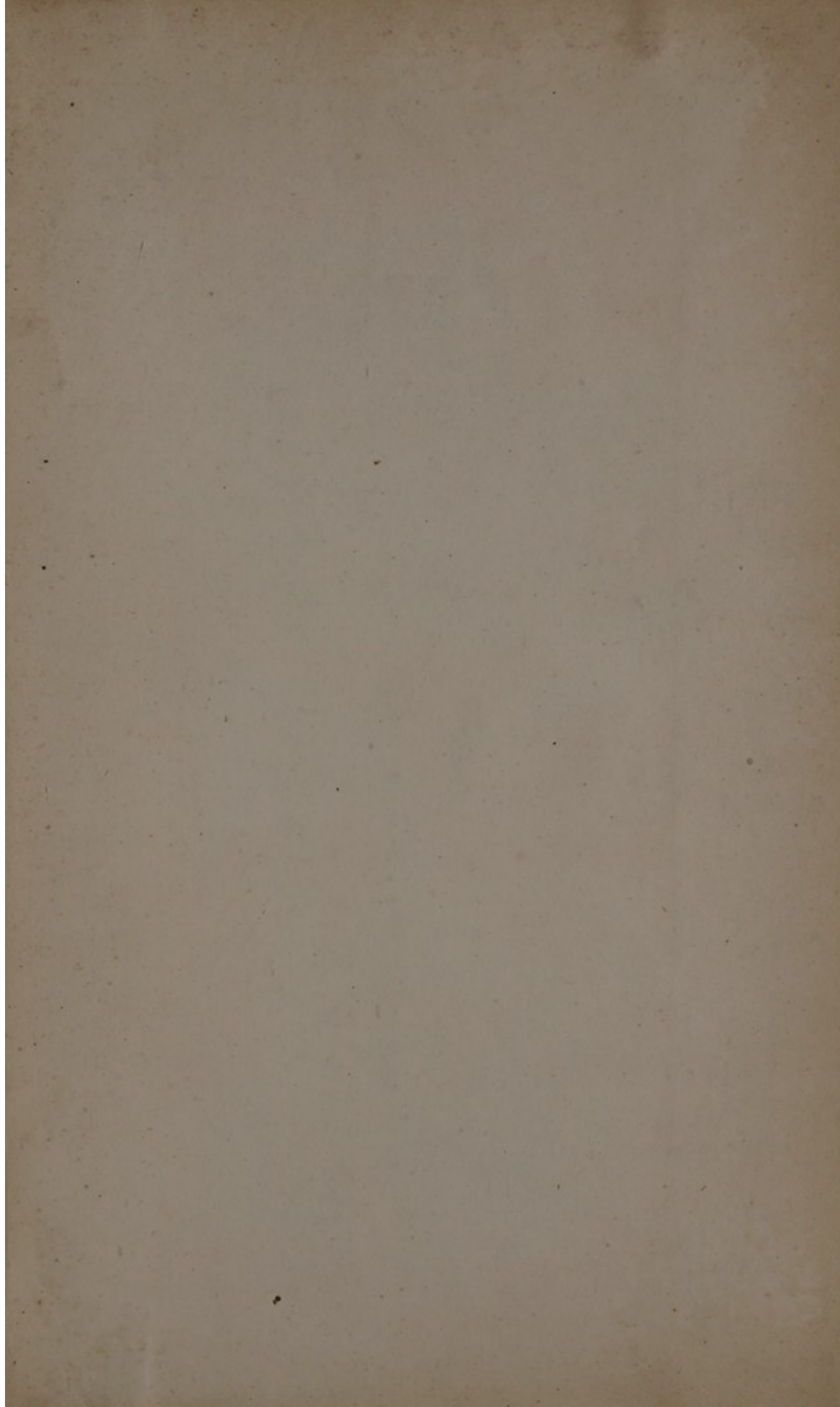
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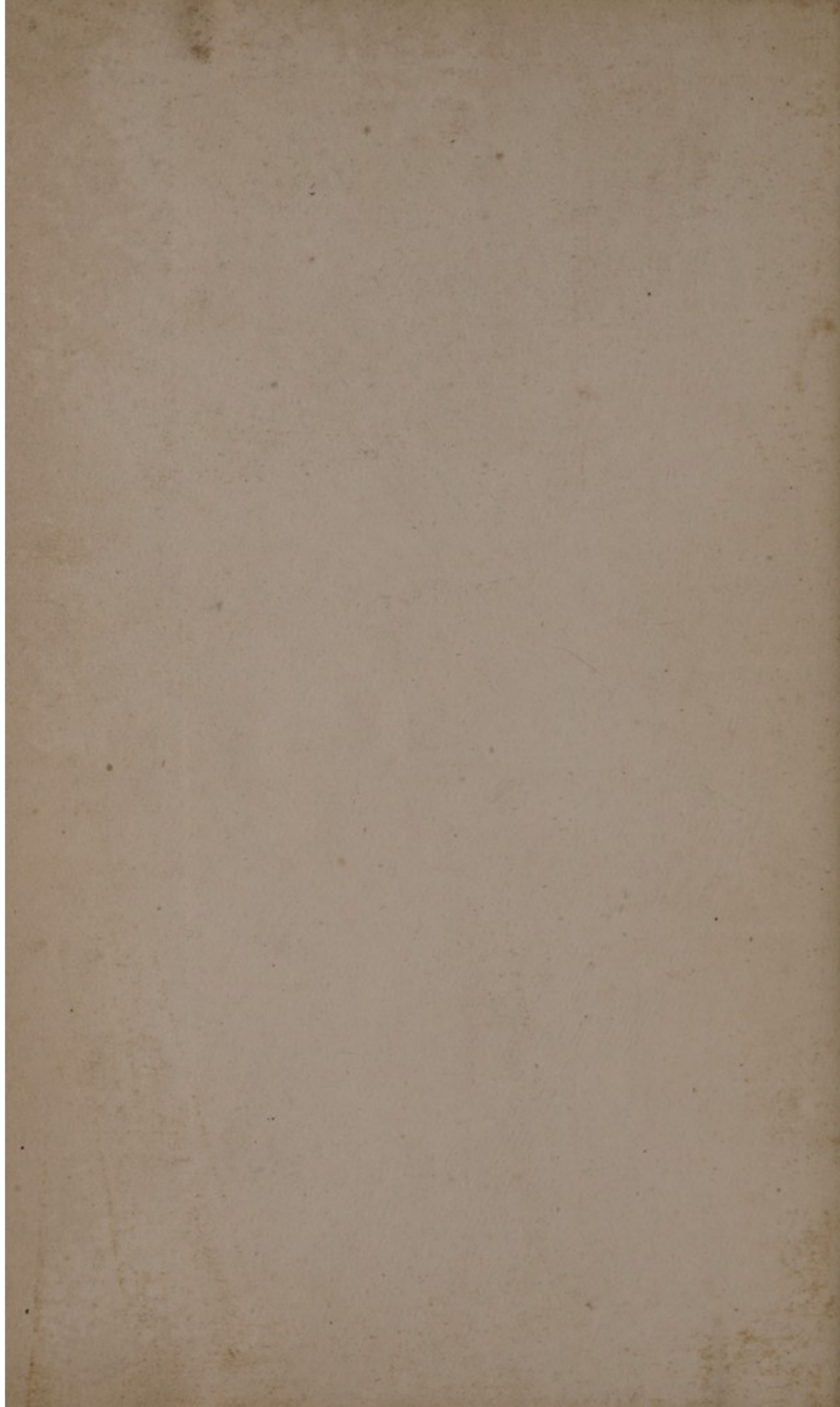












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