Extracts from the papers of Sir Charles Wheatstone

WHEATSTONE 2: Material relating to experiments designed to measure electromotile forces and electric potential, [1834-1875]

K/PP107/2/3/1-172

[1871-1873]

Working notes and rough drafts of hypotheses, methodological narratives, experimental observations and tables of test results compiled by Charles Wheatstone under the general heading of 'electro-motive forces', relating to the utility of employing combinations of elements in battery electrodes, 1871-1873; correspondence between Charles Wheatstone and Richard William Mellingford Higgs, chemist, on the analysis of acid solutions in battery experiments, with Higgs' experimental observations.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

2

Experiments on Electro-motive forces

1 Measure by the two different processes the electro-motive forces produced by the reduction of the various negative metals; the positive being 1st amalgam of zinc and 2d amalgam of sodium.

2 Ascertain whether any difference obtains when the salt is reduced on its own metals or on platinum i.e. determine whether the negative metals has any thing to do with the electro-motive force

3 Measure by the two different processes the electro-motive forces produced by the formation of the oxides of various metals amalgamated with mercury; the negative being copper or platinum.

4 Ascertain what change in the electro-motive force obtains by difference of proportion of the negative metal in the mercury.

5 The preceding experiments (3 & 4) must be made with solutions which do not attack mercury. Ascertain what results when the solution also attacks mercury.

6 Try the electro motive forces of the mixed metals as zinc & sodium &c.

7 Will any current be produced by an amalgam of zinc, sulphate of zinc, zinc. If there is it must arise from the contact of zinc & mercury

K/PP107/2/3/2
List of experiments on electromotive forces, [1871-1873],page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

8. Ascertain whether the electro-motive force of a Grove's gas element, is equal to that of the contrary electro-motive force in a voltameter.

9 Ascertain the ~~contrary~~ electromotive force, if possible, when hydrogen and chlorine, hydrogen and iodine, hydrogen & bromine &c are employed.

10 Ascertain the contrary electro-motive forces when chlorine, iodine, bromine &c are employed.

11 Compare two elements

Amal of ~~Potassium~~ Sodium .. Sulphuric acid .. Zinc

Amal of Sodium .. Sulphate of Zinc .. Zinc

The first shows the difference, the 2d the sum of the two elementary currents.

12 Measure the electro-motive forces between platinum plates of

Sulphuric acid Solution of Potass

Sulphuric acid Nitric acid.

13

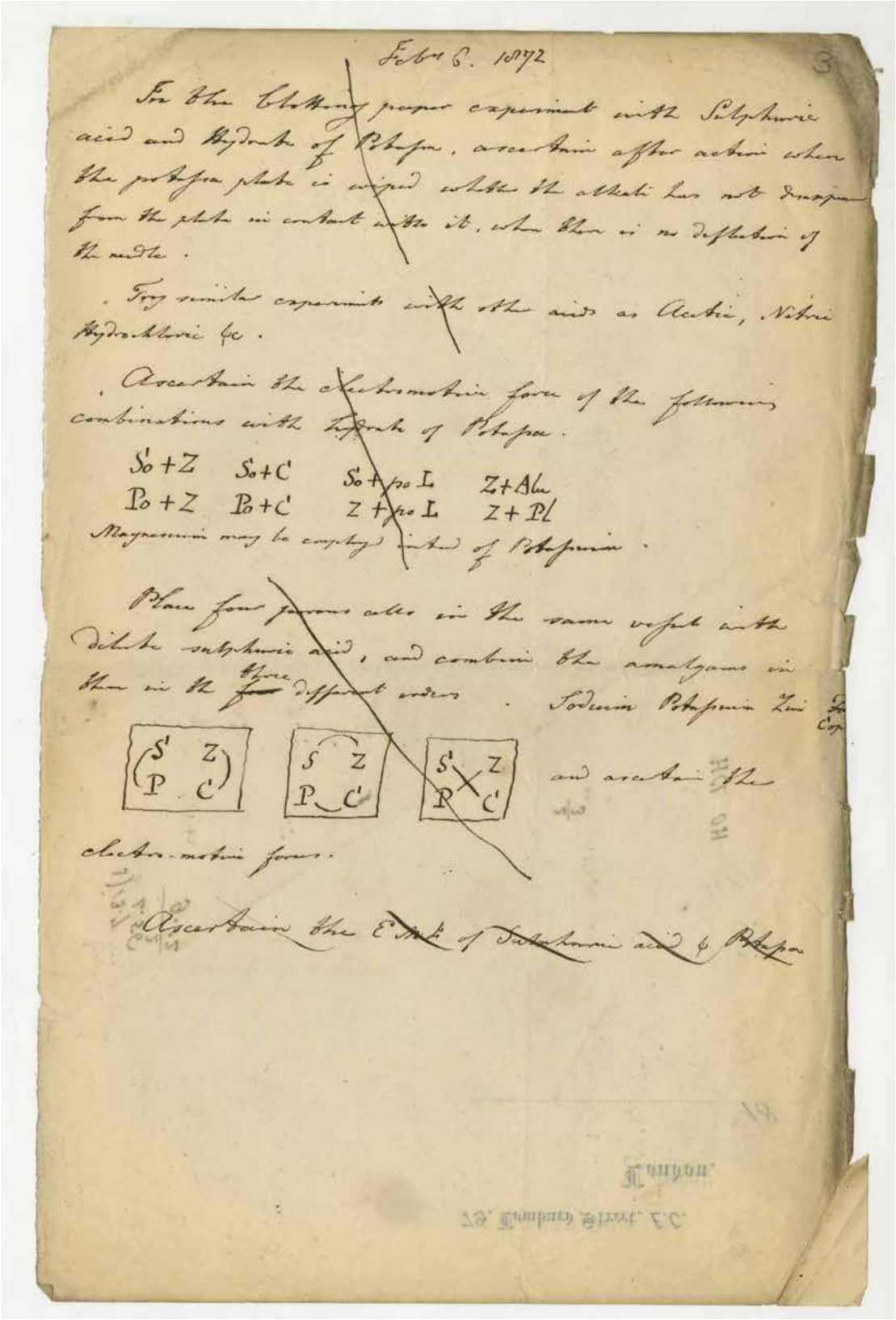
Pot Sulph Z Zinc Sulph Cop Cop

should give precisely the same as

Pot Sulph Cop Cop

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



Feby 6. 1872 3

For the blotting paper experiment with Sulphuric acid and Hydrate of Potassa, ascertain after action when the potassa plate is wiped whether the alkali has not decomposed from the plate in contact with it, when there is no deflection of the needle.

Try similar experiments with other acids as Acetic, Nitric Hydrochloric &c.

Ascertain the electromotive force of the following combinations with Hydrate of Potassa.

So + Z So + C So + pot L Z + Alu
Po + Z Po + C Z + pot L Z + Pl

Magnesium may be employed instead of Potassium.

Place four jars alike in the same vessel with dilute sulphuric acid, and combine the amalgams in them in the ~~four~~ three different orders. Sodium Potassium Zinc Copper

(S Z / P C) S Z / P C S Z / P C

and ascertain the electromotive forces.

Ascertain the E.M.F. of Sulphuric acid & Potassa

K/PP107/2/3/3

Notes on experiments to determine electromotive forces using sulphuric acid and hydrate of potassium, 1872 Feb 6.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

6

Double plate rotating apparatus.

~~Palladium~~ Aluminium & Platinum in Sulphuric acid.

Do - - - in Nitric acid

at rest and in motion.

Lead - Sulphuret of Potash - Platinum

they like it stands at 0° ... Then interpose a thermo-electric pair - the current will pass -

Observe whether on continuing the thermo-electric action equilibrium will be again obtained. If so put a wound work the thermo electric pair and the current will be produced in the opposite direction

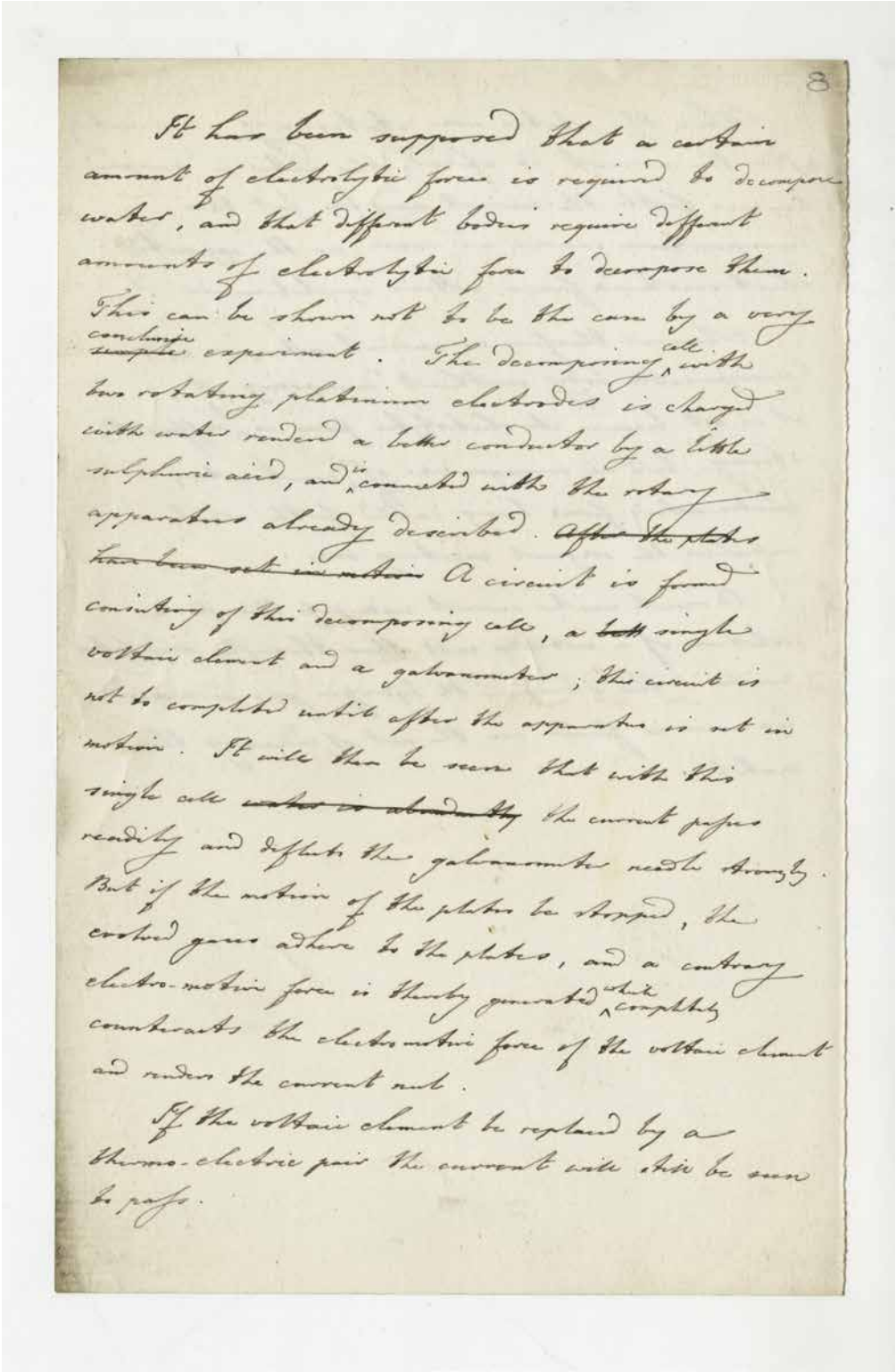
---

Zinc	Chloride of Platinum	Copper	higher
Zinc	Sulphate of Copper	Platinum	intermediate
Copper	Sulphate of Zinc	Platinum	lower
Copper	Chloride of Platinum	Platinum	same

A single standard cell with the double plate rotating decomposing cell and galvanometer. Observe whether the current passes and then measure its E.M.F.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



8

It has been supposed that a certain amount of electrolytic force is required to decompose water, and that different bodies require different amounts of electrolytic force to decompose them. This can be shown not to be the case by a very ~~simple~~ conclusive experiment. The decomposing cell with two rotating platinum electrodes is charged with water rendered a better conductor by a little sulphuric acid, and connected with the rotary apparatus already described. ~~After the plates have been set in motion~~ A circuit is formed consisting of this decomposing cell, a ~~bat~~ single voltaic element and a galvanometer; this circuit is not to completed until after the apparatus is set in motion. It will then be seen that with this single cell ~~water is abundantly~~ the current passes readily and deflects the galvanometer needle strongly. But if the motion of the plates be stopped, the evolved gases adhere to the plates, and a contrary electro-motive force is thereby generated which completely counteracts the electromotive force of the voltaic element and renders the current null.

If the voltaic element be replaced by a thermo-electric pair the current will still be seen to pass.

K/PP107/2/3/8

Note describing the decomposition of water using electrolytic force, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

When the plates are stationary, immediately after the circuit is closed the water is decomposed however feeble the current may be, but this decomposition ceases as soon as the opposite electromotive forces attain equilibrium.

Whenever therefore a current acts upon a decomposable body without decomposing it, it is not because its electrolytic force is not sufficiently strong, but in consequence of a counteracting electro-motive force being called forth which neutralizes the original exciting one.

A much weaker current will pass through a solution of a metallic salt than through acidulated water; this is because the hydrogen gas is removed as soon as formed in the act of reducing the metal.

K/PP107/2/3/8

Note describing the decomposition of water using electrolytic force, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

11

~~March~~ April 8.

1. Two platinum electrodes one fixed the other rotating. Observe if the current is from the rotating to the fixed plate. After the rotating plate has been a long time in motion ascertain if there is any salt of platinum in the solution, or if any black powder has been thrown down.

2. Two stationary platinum electrodes in the divided cell. One compartment charged with concentrated, the other with dilute nitric acid. Ascertain whether the current is from the concentrated to the dilute acid, and measure the E.M.F.

3. Ascertain whether Cadmium and Silver can be rendered passive.

4 The tartrate and sulphate of copper given with copper electrodes for c m f 170.4 from (10° to 45°) with platinum electrodes no current. Repeat these two experiments, and also by the same salts with other electrodes (both the same).

5 Try an element Zn + Nitric acid + Platinum / Aluminium and ascertain the E.M.F.

6 Will pure zinc | thrown down (chemically) iron, copper, platinum be. The test of the purity of zinc is its not being attacked by sulphuric acid.

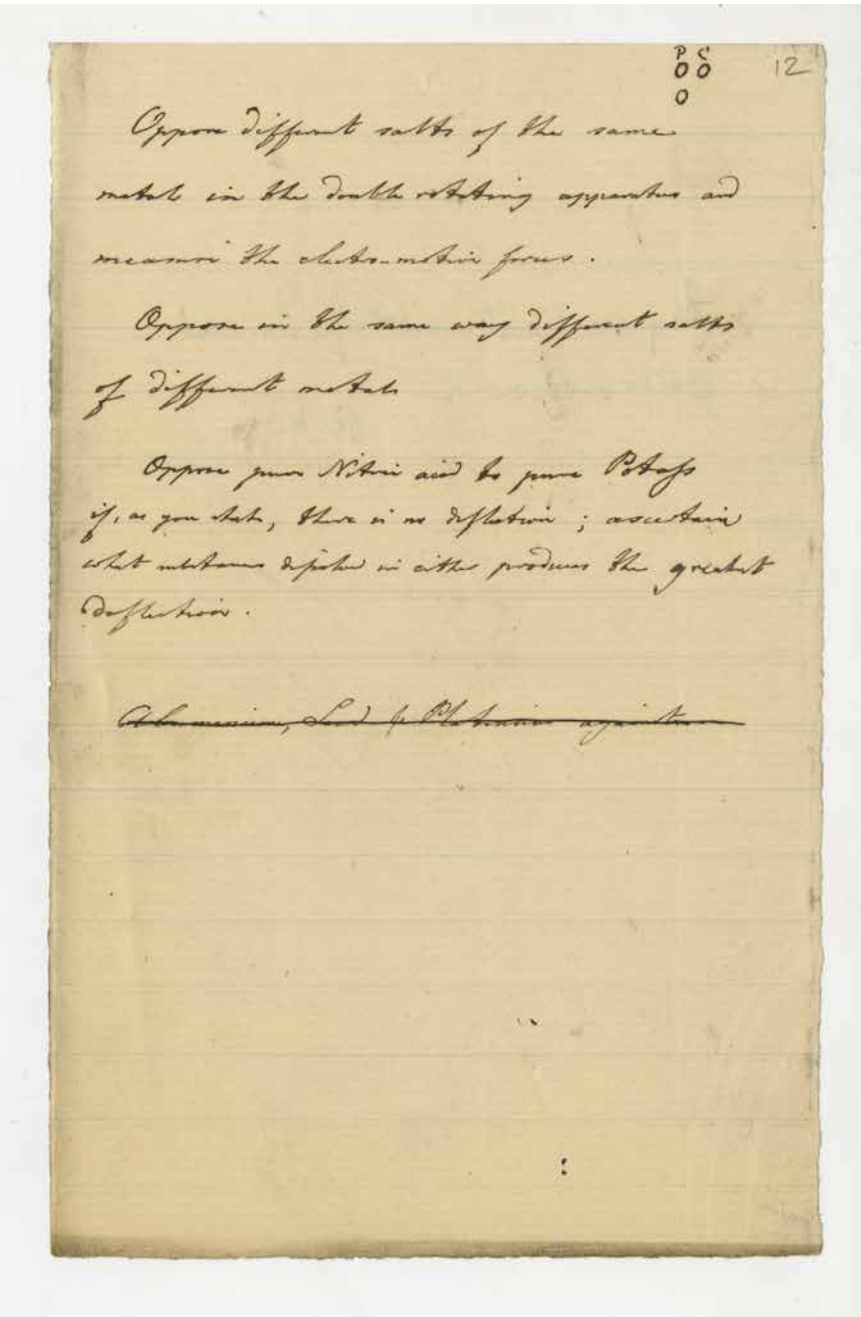
7. The E.M.F. of amorphous Carbon, and any other form of Carbon.

K/PP107/2/3/11

Notes relating to measuring the electromotive force of various elements, [1871-1873] Apr 8.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



P S
0 0
0

12

Oppose different salts of the same metal in the double rotating apparatus and measure the electro-motive forces.

Oppose in the same way different salts of different metals.

Oppose pure Nitric acid to pure Potash if, as you state, there is no deflection; ascertain what substance dissolved in either produces the greatest deflection.

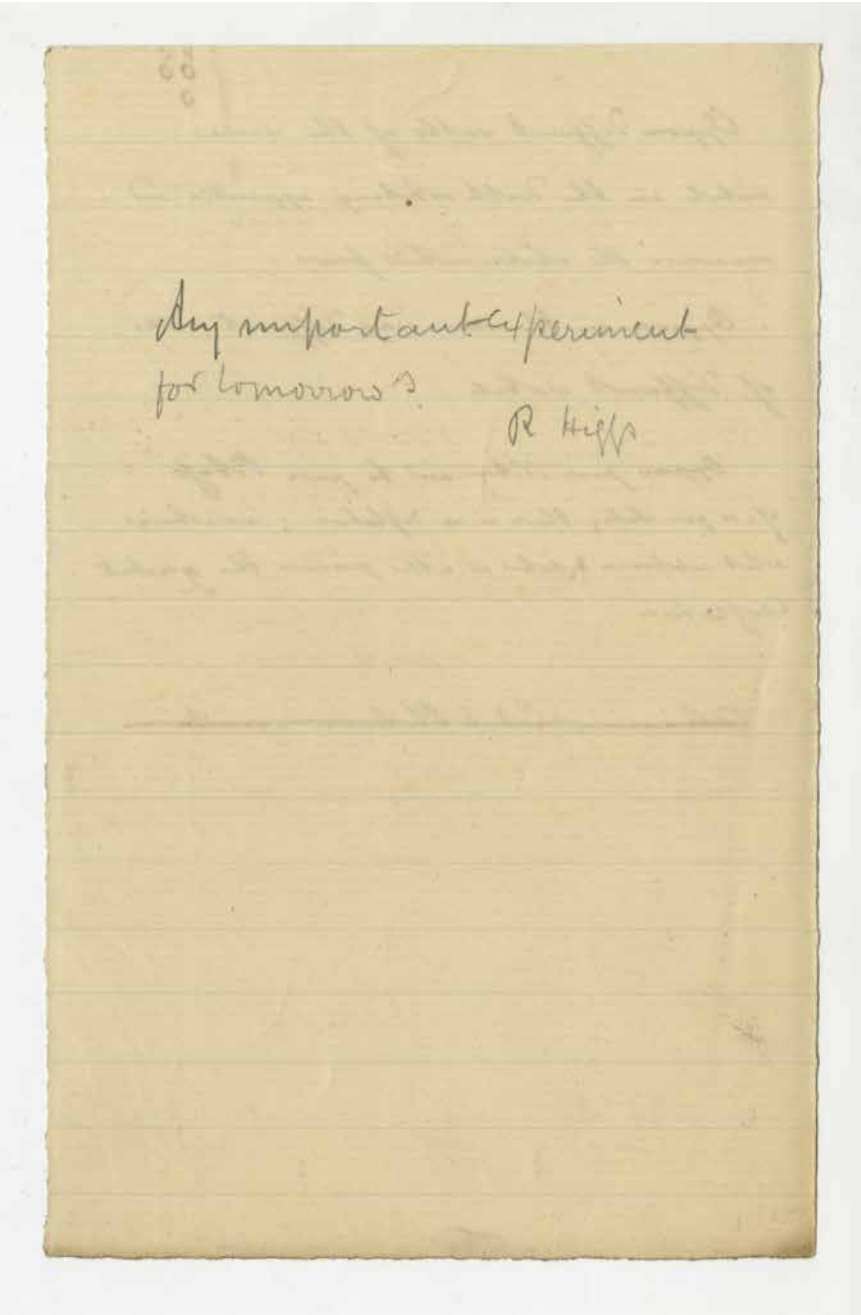
~~Ammonia, Lead & Platinum against~~

K/PP107/2/3/12

Notes describing measuring electromotive forces using a 'double rotating apparatus' with different salts, on reverse a note from Richard William Mellingford Higgs, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



Any important experiment for tomorrow?

R Higgs

K/PP107/2/3/12

Notes describing measuring electromotive forces using a 'double rotating apparatus' with different salts, on reverse a note from Richard William Mellingford Higgs, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

13

Electroscopic Experiments.

1st Formulate each element. Connect one pole to the earth and apply the electrometer to the other pole. Repeat each experiment inverting the poles

2. Let each pole remain unconnected with the earth. Apply the electrometer successively to each pole.

3 Divide an element by removing one of the electrodes. Apply the electroscope successively to the positive and negative electrode

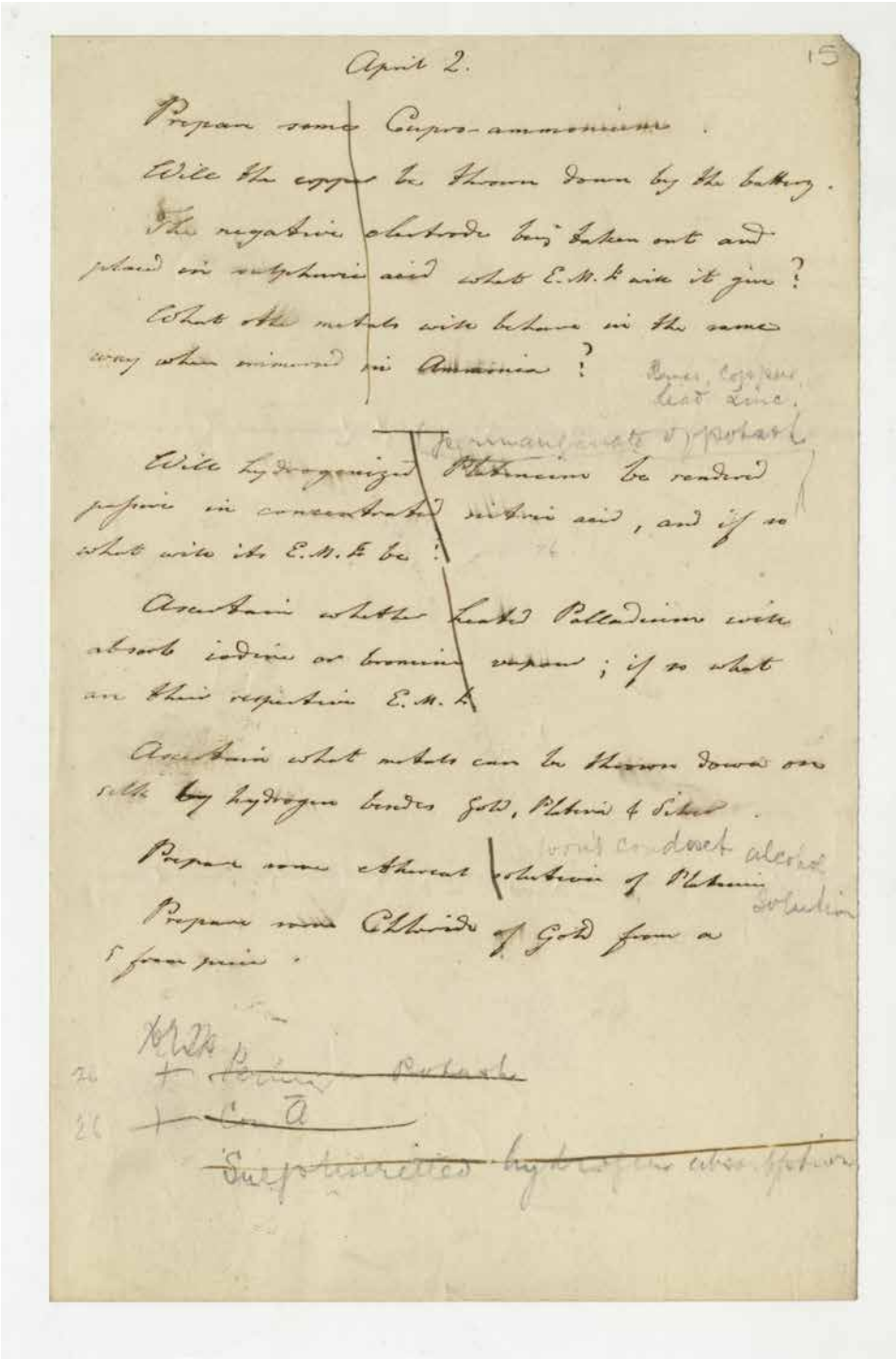
4 Measure the electroscopic force of metals only in contact.

K/PP107/2/3/13

List of 'electrocopic experiments', [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



April 2. 15

Prepare some Cupro-ammoniume.

Will the copper be thrown down by the battery.

The negative electrode being taken out and placed in sulphuric acid what E.M.F will it give?

What other metals will behave in the same way when immersed in Ammonia?

Zinc, Copper, lead zinc.

Will hydrogenized Platinum be rendered passive in concentrated nitric acid, and if so what will its E.M.F be?

permanganate of potash

Ascertain whether heated Palladium will absorb iodine or bromine vapour; if so what are their respective E.M.F.

Ascertain what metals can be thrown down on silk by hydrogen binder Gold, Platinum & Silver.

Prepare some ethereal solution of Platinum

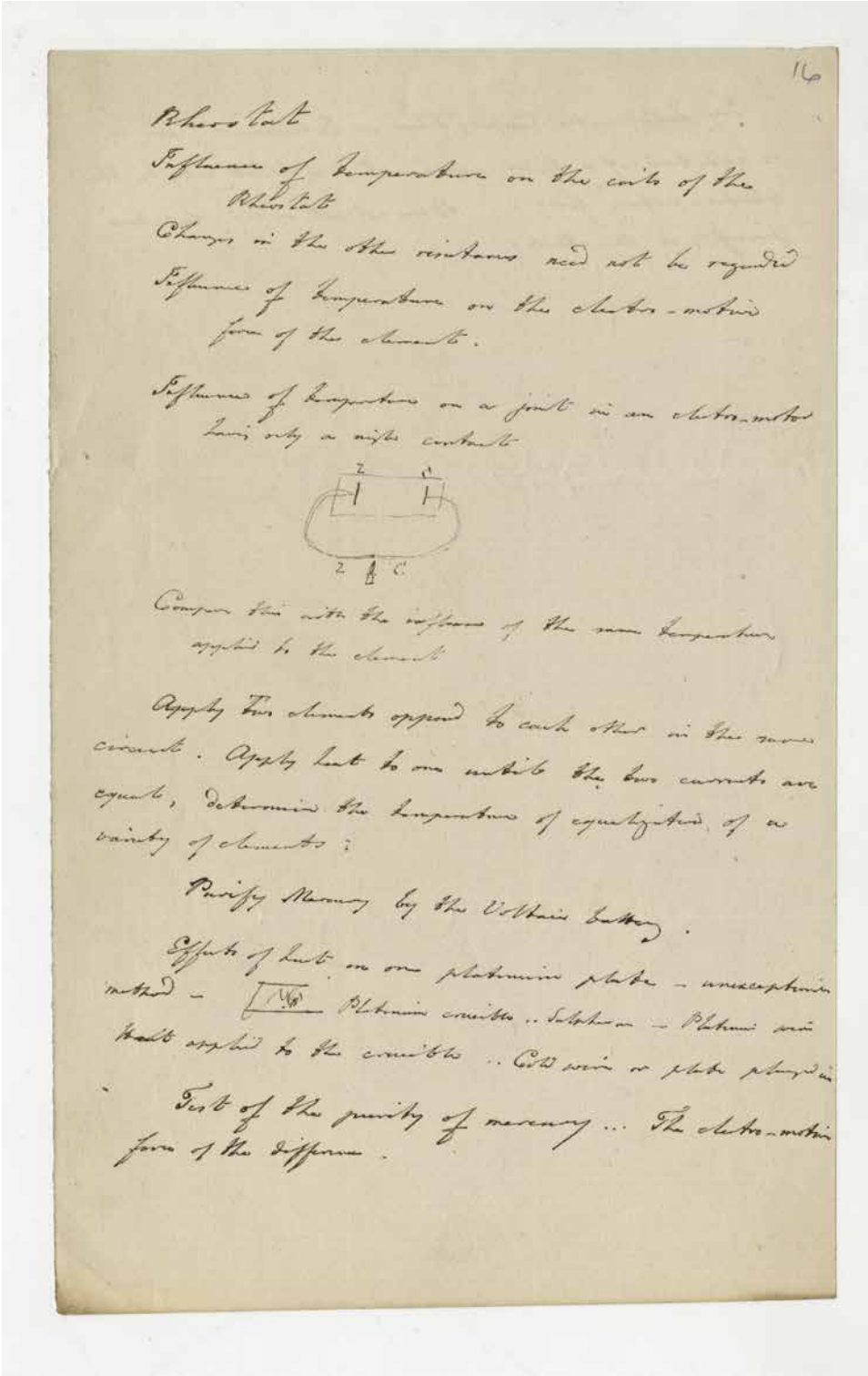
Prepare some Chloride of Gold from a 5 fine.

Prepare ~~Potash~~

~~Sulphuretted hydrogen also sulphur~~

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



16

Rheostat

Influence of temperature on the coils of the Rheostat

Changes in the other resistances need not be regarded

Influence of temperature on the electro-motive force of the element.

Influence of temperature on a joint in an electro-motor having only a single contact

Compare this with the influence of the same temperature applied to the element

Apply two elements opposed to each other in the same circuit. Apply heat to one until the two currents are equal, determine the temperature of equilibrium of a variety of elements:

Purify Mercury by the Voltaic battery.

Effects of heat on one platinum plate – unexceptionable method – [illegible] Platinum crucible .. Sulphur – Platinum wire heat applied to the crucible .. Cold wire or plate plunged in

Test of the purity of mercury ... The electro-motive force of the different.

K/PP107/2/3/16

Notes and rough diagram describing the use of a rheostat, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

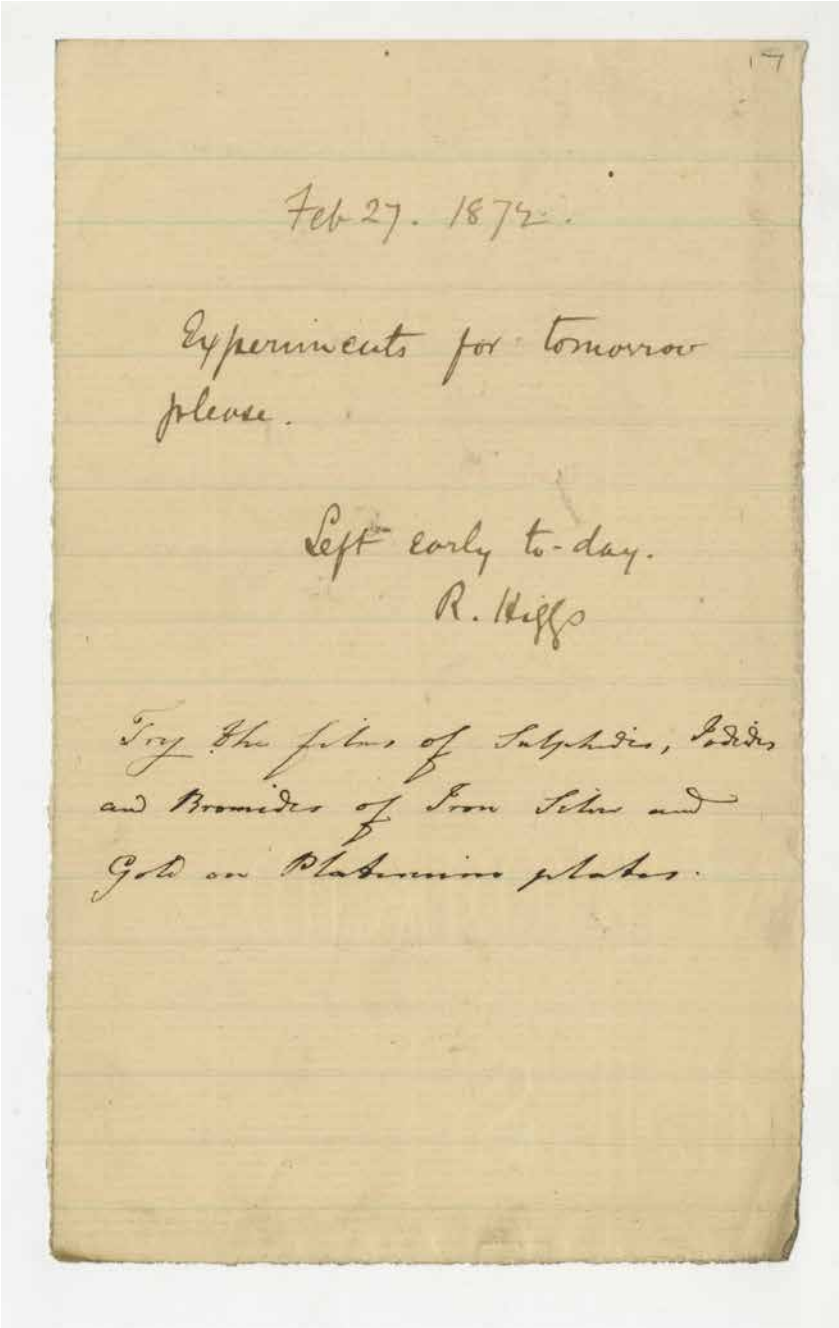
For Zinc with Copper, Silver or Palladium, in a solution of a hydro-sulphuret – What will be the electro-motive force. It does not act on Zinc but does powerfully on the other.

K/PP107/2/3/16

Notes and rough diagram describing the use of a rheostat, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



17

Feb 27. 1872.

Experiments for tomorrow please.

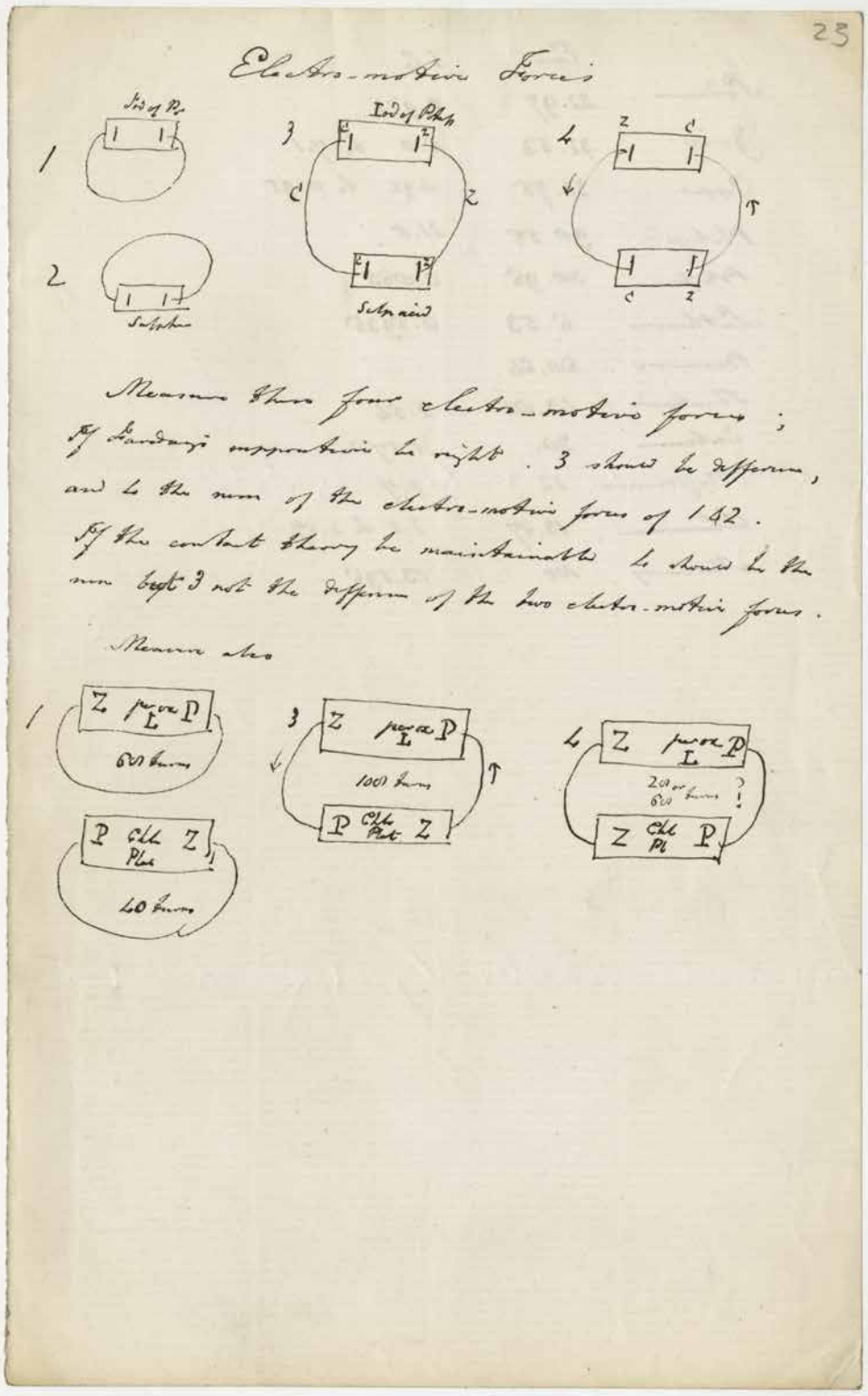
Left early to-day.
R. Higgs

Try the films of Sulphides, Iodides and Bromides of Iron Silver and Gold on Platinum plates.

K/PP107/2/3/17
Notes between Richard William Mellingford Higgs and Wheatstone regarding experiments to be tried, 1872 Feb 27.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



K/PP107/2/3/23

Notes and rough diagrams on experiments to measure electromotive forces, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

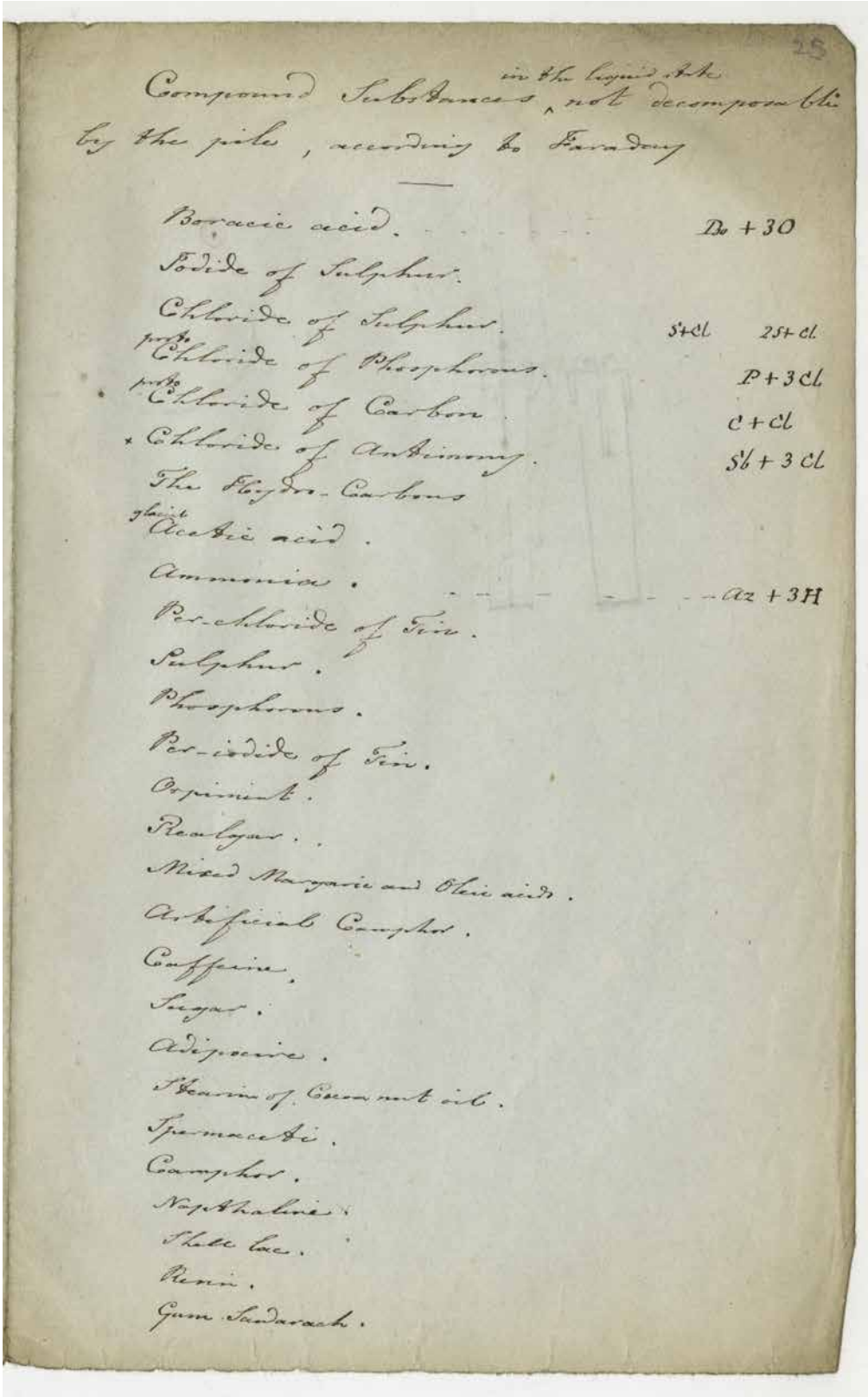
	Equ	SG
Sodium	22.97	0.972
Zinc	32.52	6.8 to 7.1
Copper	31.75	8.92 to 8.95
Platinum	98.56	21.5
Potassium	38.96	0.865
Lithium	6.53	0.5936
Barium	68.64	
Strontium	43.84	2.54
Calcium	20.	1.578
Magnesium	12	1.7
Aluminum	13.67	2.5 to 2.67
Mercury	100.	13.596

K/PP107/2/3/23

Notes and rough diagrams on experiments to measure electromotive forces, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



25

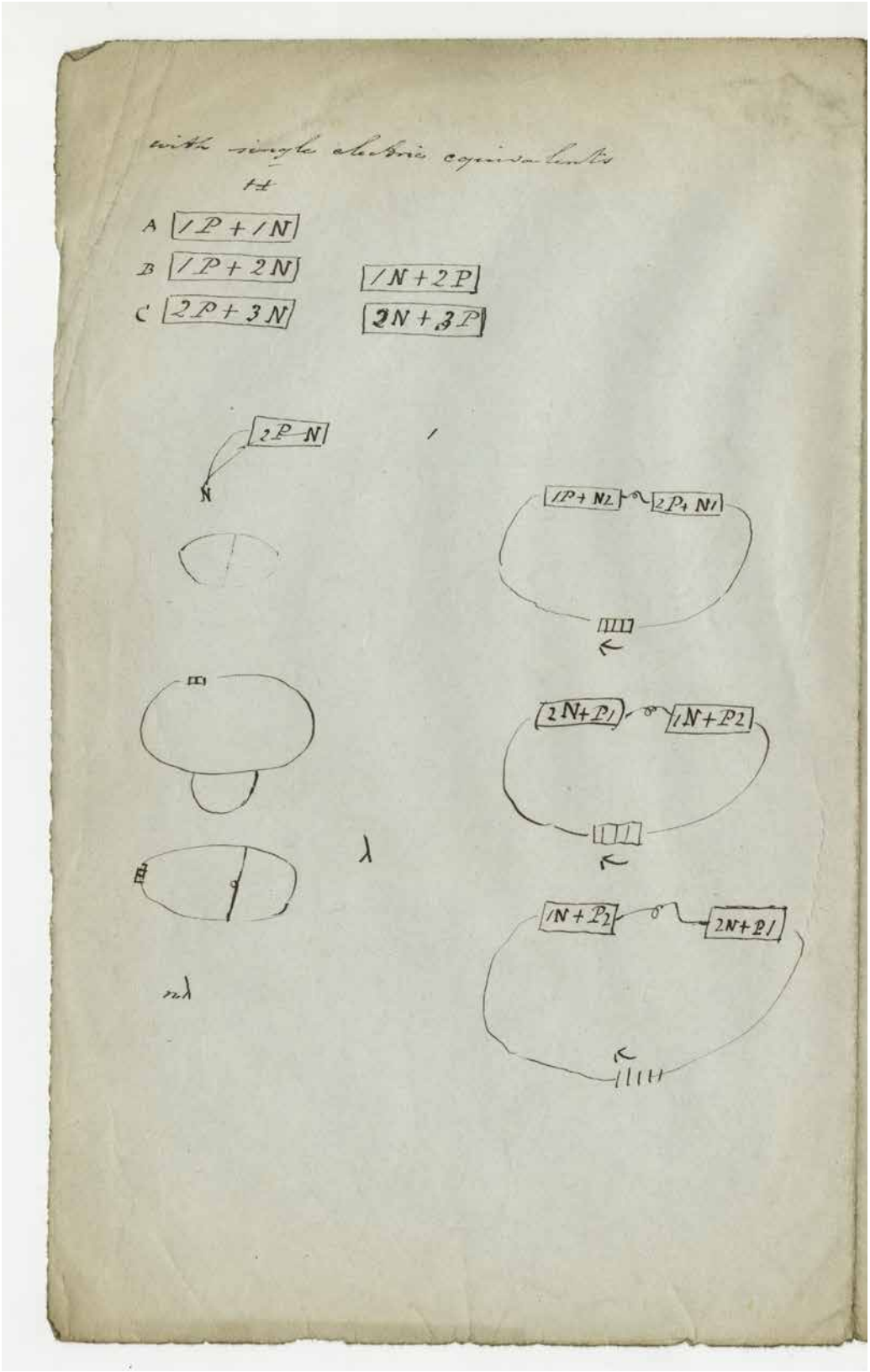
Compound Substances in the liquid state not decomposable by the pile, according to Faraday

Boracic acid. — Bo + 3O
Iodide of Sulphur.
Chloride of Sulphur. — S+Cl — 2S+Cl
prob. Chloride of Phosphorus. — P+3Cl
prob. Chloride of Carbon — C+Cl
× Chloride of Antimony. — Sb + 3 Cl
The Bicyclo-Carbons
Acetic acid.
Ammonia. — Az + 3H
Per-chloride of Tin.
Sulphur.
Phosphorus.
Per-iodide of Tin.
Orpiment.
Realgar.
Mixed Margaric and Oleic acids.
Artificial Camphor.
Caffeine.
Sugar.
Adipocire.
Stearine of Cocoa nut oil.
Spermaceti.
Camphor.
Napthaline.
Shell lac.
Resin.
Gum Sandarach.

K/PP107/2/3/25
List of 'compound substances in the liquid state by the pile, according to Faraday', includes rough diagrams, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



K/PP107/2/3/25

List of 'compound substances in the liquid state by the pile, according to Faraday', includes rough diagrams, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

27

June 19. 1871

1. Measure the electro-motive force of a C + Sul Cop + Z cell from 45° to 40°

2. Substitute a platinum for a copper plate in the preceding experiment.

3 Try the amalgam with different weighted proportions of Z (Copper being employed for the other plate) and ascertain the changes, if any of the electro-motive force.

4 Heat the cell with a spirit lamp and ascertain if there is any change in the electro-motive force.

5 Measure the electro-motive force of a cell Amal of Sodium + Sul Cop + Cop.

6 Prepare two standard cells (Sodium & Cop) (Zinc & Cop) and measure them 1st with the same galvanometer between different degrees. 2d with different galvanometers between the same degrees. This will show that the strength of the current does not affect the proportionality of the electro-motive forces.

K/PP107/2/3/27

List of experiments to try and measurements to take, 1871 Jun 19, page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

✓ 7 For the standard cell try copper plates, wire, hinges &c and ascertain whether the electro-motive force remains unchanged.

8 Place a drop of sulphate of copper on a zinc plate, from contact with a copper plate and ascertain the electro-motive force

✓ 9 Ascertain whether the electro-motive force of metallic Z is the same as that of Amal of Z

10 Ascertain whether the inactivity of mercury depends on the want of action of sulphuric acid upon it, by employing nitrate of copper.

11 Measure the polarization (of the platinum wire of a voltameter) with different intensities of current. Each comparison must be made with a standard element.

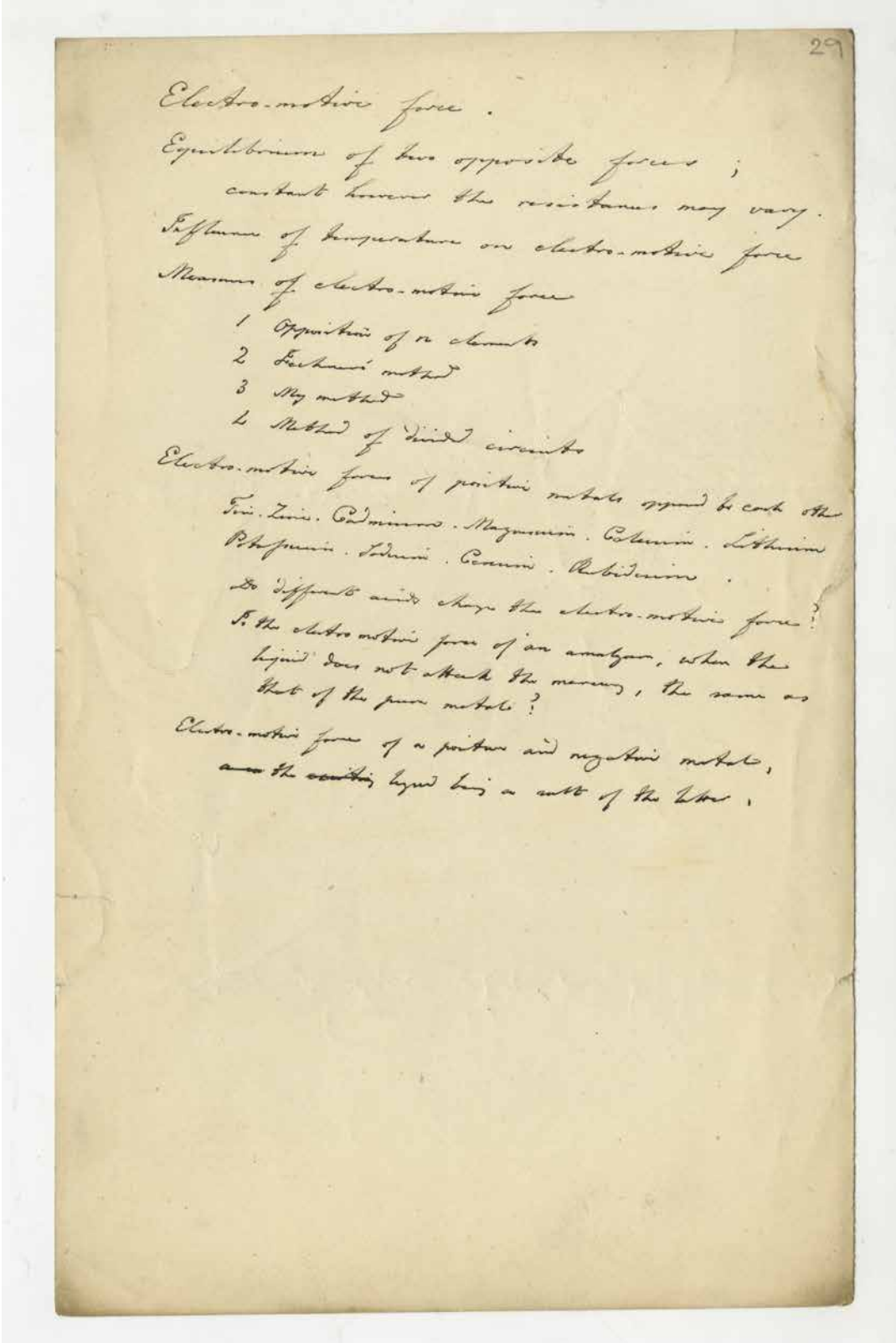
12 Measure the electro-motive force of a cell (C + Sol Cop + Z) without diaphragm.
See whether fumes of sulphur prevents the deposition of the copper upon the Z amalgam.

K/PP107/2/3/27

List of experiments to try and measurements to take, 1871 Jun 19, page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



29

Electro-motive force.

Equilibrium of two opposite forces;
constant however the resistance may vary.

Influence of temperature on electro-motive force

Measure of electro-motive force

1 Opposition of a battery
2 Fechner's method
3 Mag method
4 Method of divided circuits

Electro-motive force of positive metals supposed to rank the
Iron. Zinc. Cadmium. Magnesium. Calcium. Lithium
Potassium. Sodium. Cæsium. Rubidium.

Do different acids change the electro-motive force?

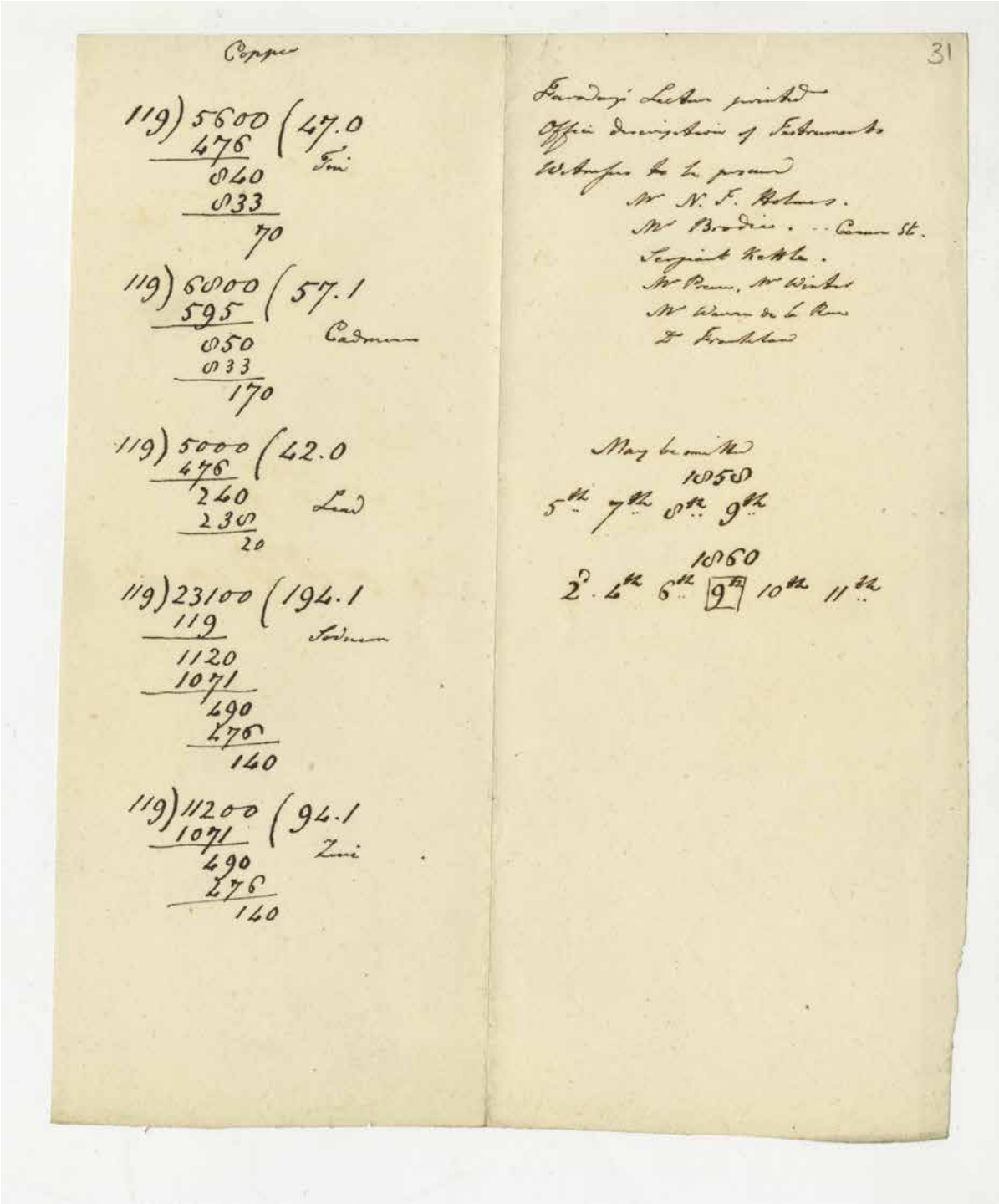
Is the electro motive force of an amalgam, when the liquid does not attack the mercury, the same as that of the pure metals?

Electro-motive force of a positive and negative metal, ~~and the exciting~~ liquid being a salt of the latter.

K/PP107/2/3/29
List of observations related to electromotive forces, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



Copper

119) 5600 (47.0
476
840
833
70

Tin

119) 6800 (57.1
595
850
833
170

Cadmium

119) 5000 (42.0
476
240
238
20

Lead

119) 23100 (194.1
119
1120
1071
490
476
140

Sodium

119) 11200 (94.1
1071
490
476
140

Zinc

31

Faraday's Lecture printed
Office description of Instruments
Witnesses to be proved
Mr N. J. Holmes.
Mr Brodie. – Conn St.
Sergeant Kettle.
Mr Pum, Mr Wicks
Mr Warren de la Rue
Dr Frankland

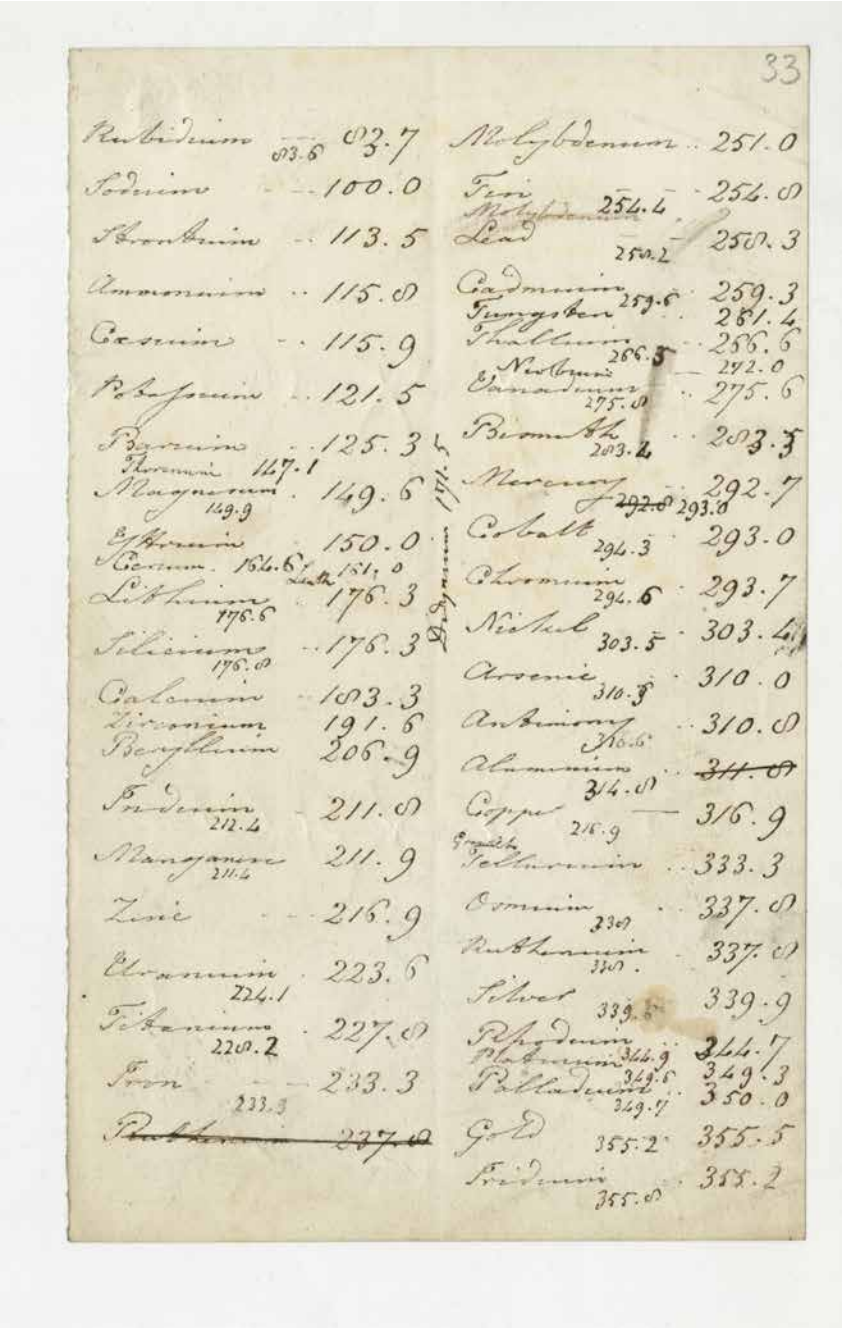
May be omitted
1858
5th 7th 8th 9th
1860
2d 4th 6th 9th 10th 11th

K/PP107/2/3/31

Calculations relating to various elements and a list including 'Faraday's Lecture printed', 'office description of instruments', and witnesses including Nathaniel John Holmes, [1824]-1888, electrical engineer, Warren de la Rue (1815-1889), chemist and astronomer, Edward Frankland (1825-1899), chemist, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



33

Rubidium	83.7	Molybdenum	251.0
Sodium	100.0	Tin	254.0
Strontium	113.5	Lead	250.3
Ammonium	115.0	Cadmium	259.3
Caesium	115.9	Tungsten	261.4
Potassium	121.5	Thallium	266.6
Barium	125.3	Niobium	272.0
Magnesium	149.6	Vanadium	275.6
Calcium	150.0	Bromine	283.5
Lithium	176.3	Mercury	292.7
Silicium	176.3	Cobalt	293.0
Cerium	183.3	Chromium	293.7
Zirconium	191.6	Nickel	303.4
Beryllium	206.9	Arsenic	310.0
Yttrium	211.0	Antimony	310.0
Manganese	211.9	Aluminium	~~311.0~~
Zinc	216.9	Copper	316.9
Chromium	223.6	Tellurium	333.3
Titanium	227.0	Bismuth	337.0
Iron	233.3	Ruthenium	337.0
~~Ruthenium~~	~~237.0~~	Silver	339.9
		Rhodium	344.7
		Platinum	349.3
		Palladium	350.0
		Gold	355.5
		Iridium	358.2

K/PP107/2/3/33

List of elements and associated figures [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

36

Conversion of Electricity into Heat

1st Experiment .. An insulated metal plate.

Two arms insulated from each other, and connected respectively with the two coatings of a large charged jar or battery, vibrate so as alternately touch the plate. The plate first receives a charge from a, which is neutralized by the charge from b', and this occurring succeeding many times will probably generate heat indicated by a delicate thermometer inserted in the plate.

2d Experiment. To produce cold .. The plate C to be placed between two other plates A and B. A is charged positively and induces negative electricity on the opposite face of C, the positive electricity is then abstracted; B is then charged negatively and induces positive electricity on the opposite face of C, which is also abstracted. The operation being continued many times both electricities being removed, cold is produced. Instead of two inducing plates A & B, a single plate may be employed alternately charged with positive and negative electricity.

The electricities by combining lose their expansive force.

K/PP107/2/3/36

Notes describing experiments relating to the 'conversion of electricity into heat', [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

46

	Strides	from 50° to 55°		Turns
Amalg of Zinc	30	Sulphate of Copper	Copper	25
Amalg of Zinc	26	Acetate of Iron	Iron	17
— — —	24	Nitrate of Iron	Iron	17
— — —	8.4	Chloride of Tin	Tin	7
— — —	13.2	Nitrate of Lead	Lead	11
— — —	12	Nitro-muriate of Antimony	Antimony	10
— — —	9.6	Nitrate of Bismuth	Bismuth	8
Amalg of Potass	80	Sulphate of Copper	Copper	50
— — Sodium	64.1	do	Copper	54
		from 20 to 25		
Amalg of Zinc	30	Sulphate of Copper	Copper	40
— — —	13.2	Acetate of Lead	Lead	17½
— — Sodium	43.4	Sulphate of Nickel	Nickel 37.5	60
— — Sodium	49	Sulphate of Copper	Copper	65
— — Sodium	45	Acetate of Cobalt	Cobalt	50

Z T B A L I C Pl
Z 1 8.4 9.6 12 13.2 24 30 40
Eq 29 80 89

K/PP107/2/3/46
Table showing various amalgams and chemical compounds together with related number of turns of the rheostat, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

48

	Sodium	K	Zn	Cu	Pt	PtO_2
Na	0	+	+	+	+	+
NH_4	+	+	+	+	+	+
K	+	0	+	+	+	+
Mg	+	+	+	+	+	+
Ba	+			+		
Li	+	+	+	+	+	+
Mn	+	+	1	+	+	+
Zn	+	+	0	100	+	+
Indium	+	+	+	+	+	+
U	+	+	+	+	+	+
Fe	+	+	+	+	+	+
Sn	+	+	+	+	+	+
Pb	+	+	+	+	+	+
Cd	+	+	+	+	+	+
Hl	+	+	+	+	+	+
Bi	+	+	+	+	+	+
Hg	+	+	+	+	+	+
Co	+	+	+	+	+	+
Ni	+	+	+	+	+	+
Sb	+	+	+	+	+	+
As	+	+	+	+ ~~Imperfectly~~	+	+
Al	+	+	+	+ ~~Imperfectly~~	+	+
Cu	+	+	100	0	+	+
Te	+	+	+	+	+	+
Ag	+	+	+	+	+	+
Pt	+	+	+	+	0	+
Pd	+	+	+	+	+	+
Cr	+	+	+	+	+	+
Au	+	+	+	+	+	+
Iridium	+	+	+	+	+	+
MnO_2	+	+	+			
PtO_2	+	+	+	+	+	0
HlO_2	+	+	+	+	+	+
AgO_2	+	+	+	+	+	+
BiO_3	+	+	+	+	+	+
SnO_2	+	+	+	+	+	+
IrO_2	+	+	+	+	+	+
AuO_3	+	+	+	+	+	+

K/PP107/2/3/48

Table of chemical elements and their positivity when combined with other elements including sodium, potassium, and zinc, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

50

July 7th 1871.

Sir Charles Wheatstone,

My dear Sir,

You will find I have arranged the chemicals sent from Griffin's. Anything further to-day I beg you will pardon: I find myself, by a letter this morning, involved in a legal affair relating to some money of my wife's that requires immediate attention. To-morrow, or this afternoon, I will remain later, should you desire it. I say this afternoon with the proviso that I am able to return in time.

I am, Very faithfully Yours
R M Higgs

K/PP107/2/3/50

Letter to Wheatstone from Richard William Mellingford Higgs regarding his absence, 1871 Jul 7.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

51

Mr. Becker tested the Thermo-electric Hygrometer before me and it worked admirably. He tells me that the wire of the galvanometer should not have more than half a B.A. unit resistance; those explains are at least 14 to 15 units resistance.

Mr. Becker will send the Hygrometer.

The Mercury was 3/- a pound. 5½ lbs. where all that could be spared me. 6d was charged for the bottle.

I will keep Griffin's bill until to-morrow. They wished to send

K/PP107/2/3/51

Note possibly from Richard William Mellingford Higgs to Wheatstone including references to a Mr Becker testing a thermoelectric hygrometer, a bill from Griffins, the instrument makers, and a book by Richard Spelman Culley ([1819]-1901), telegraph engineer, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

at 8 o'clock this Evening: I told them to send at 10 tomorrow morning.

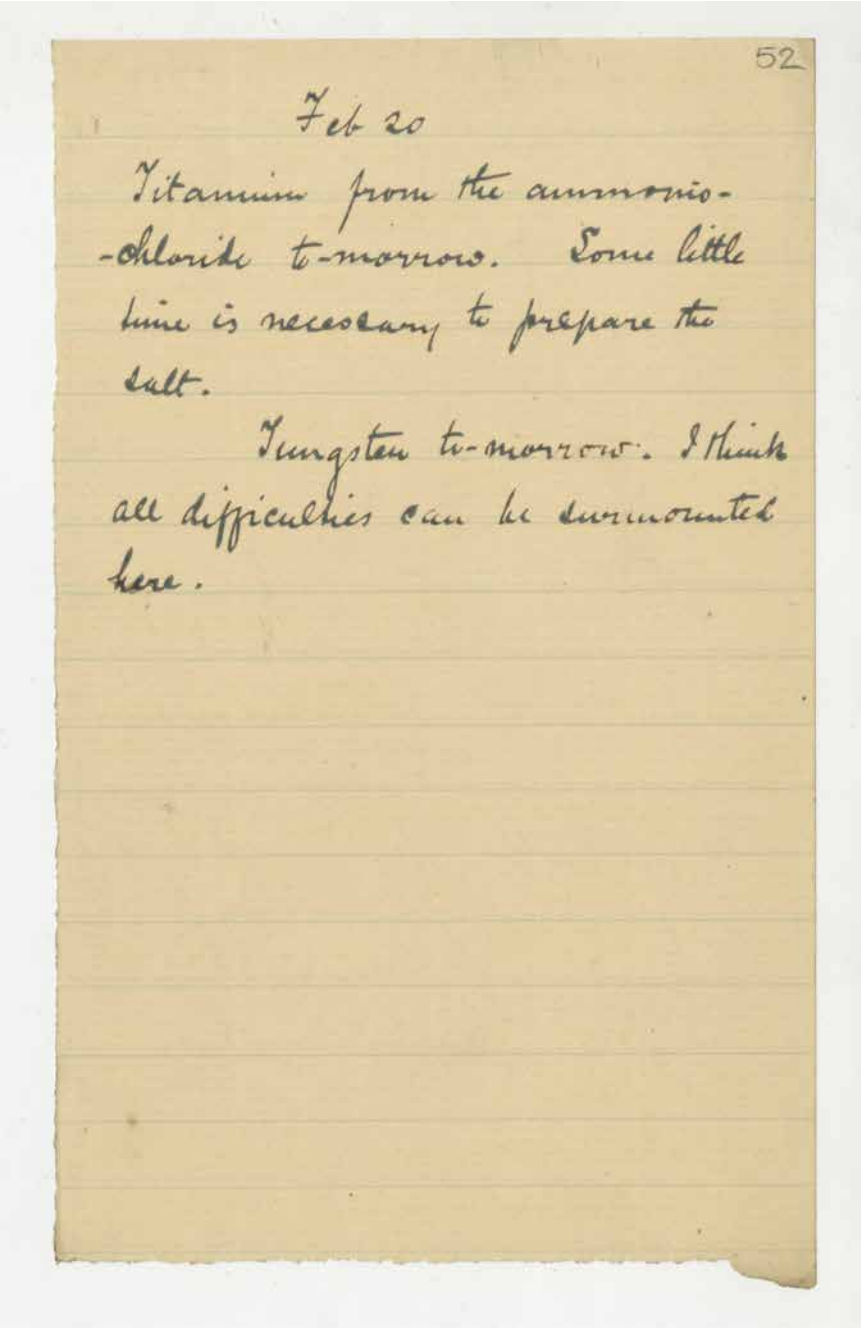
Coomes will send the <u>last</u> edition of Mr. Culley's book this Evening.

K/PP107/2/3/51

Note possibly from Richard William Mellingford Higgs to Wheatstone including references to a Mr Becker testing a thermoelectric hygrometer, a bill from Griffins, the instrument makers, and a book by Richard Spelman Culley ([1819]-1901), telegraph engineer, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



52

Feb 20

Titanium from the ammonio-
-chloride to-morrow. Some little
lime is necessary to prepare the
salt.

Tungsten to-morrow. I think
all difficulties can be surmounted
here.

K/PP107/2/3/52

Note by Richard William Mellingford Higgs outlining work completed that day on titanium and on tungsten to do the following day, [1871-1873] Feb 20.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

K/PP107/2/3/55

Ink stained and possibly acid burnt sheet of notes, probably by John Rymer Jones (1851-[1919]), chemist and electrical engineer, [1871-1873], page 1.

The Papers of Charles Wheatstone

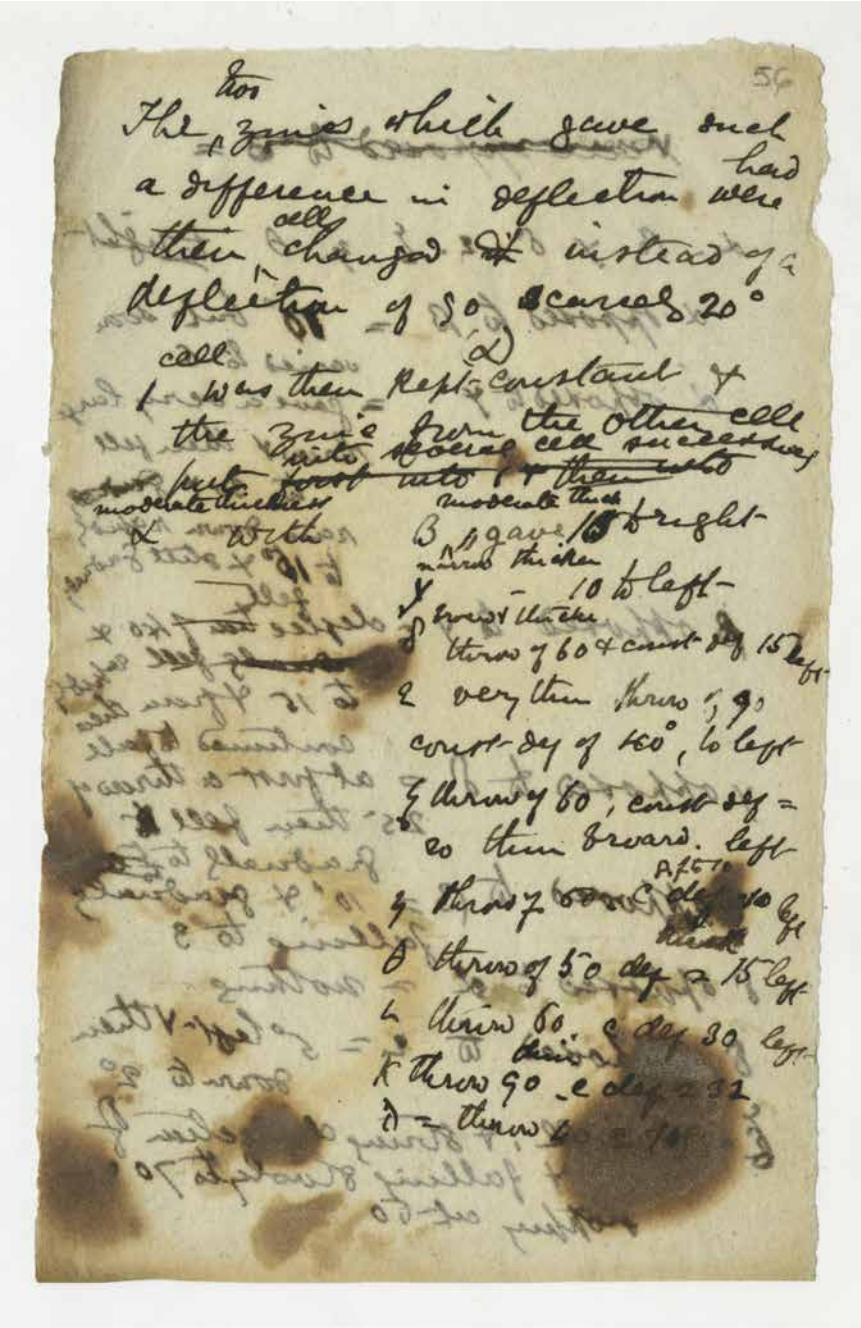
K/PP107/2/3 - Papers relating to the development of the electric telegraph

K/PP107/2/3/55

Ink stained and possibly acid burnt sheet of notes, probably by John Rymer Jones (1851-[1919]), chemist and electrical engineer, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



The zincs which gave such a difference in deflection were then changed & instead of a deflection of 50 carried 20°

1 was then kept constant & the zincs from the other cell successively put into the cell

α with moderate thickness

β gave 15 bright moderate thick

γ 10 to left more thick

δ throw of 60 & constant dev 15 left

ε over thin throw 90 constant dev of 160°, to left

ζ throw of 60, constant dev = so then towards left

η throw of 60 & dev 40 left After

θ throw of 50 dev = 15 left

ι throw 60 & dev 30 left

κ throw 90 & dev = 32

λ = throw

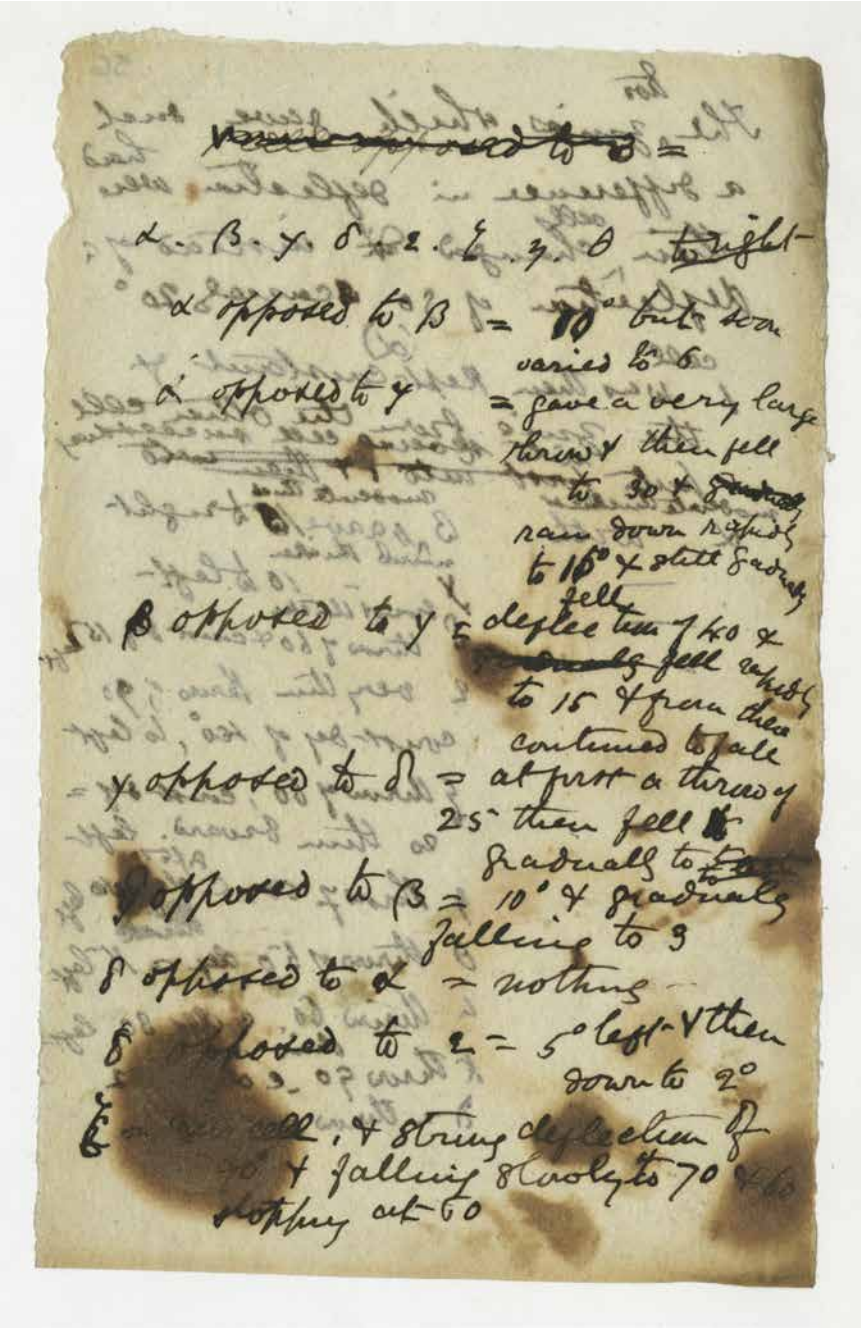
56

K/PP107/2/3/56

Rough notes on zincs by probably by John Rymer Jones (1851-[1919]), chemist and electrical engineer, page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



α . β . γ . δ . ε . ζ . η . θ ~~to right~~

α opposed to β = 70° but soon varied to 6

α opposed to γ = gave a very large throw & then fell to 30 & ~~gradually~~ ran down rapidly to 16° & slow gradually fell

β opposed to γ = deflection of 40 & ~~gradually~~ fell rapidly to 15 & from there continued to fall

γ opposed to δ = at first a throw of 25° then fell gradually to ~~[illegible]~~ to

β opposed to β = 10° & gradually falling to 3

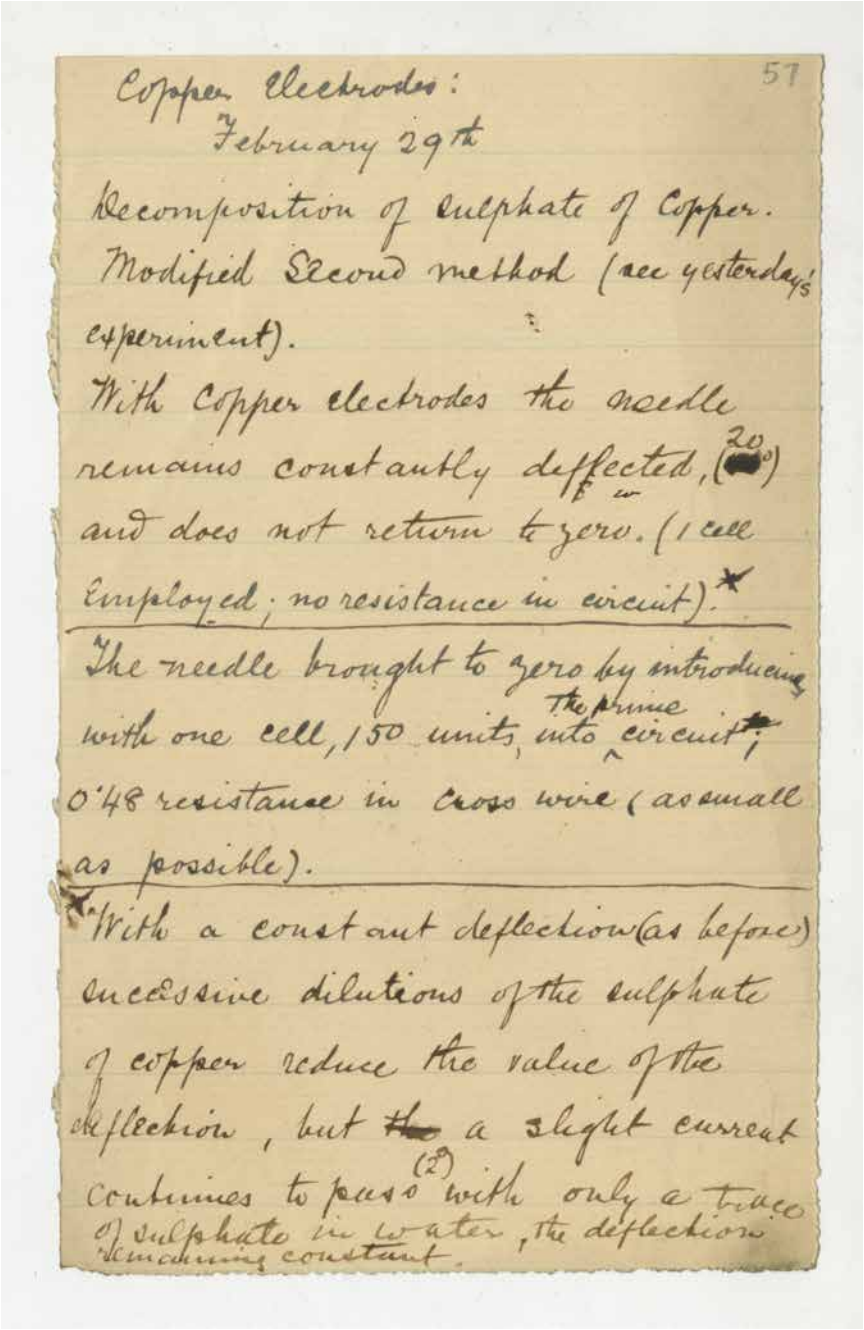
δ opposed to α = nothing

δ opposed to ε = 5° left & then down to 2°

ζ [illegible] & strong deflection of 90° & falling slowly to 70 & 60 stopping at 60

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



57

Copper electrodes:
February 29th

Decomposition of sulphate of Copper.
Modified Second method (see yesterday's experiment).

With Copper electrodes the needle remains constantly deffected, (20°) and does not return to zero. (1 cell Employed; no resistance in circuit).*

The needle brought to zero by introducing with one cell, 150 units, the prime into circuit; 0·48 resistance in cross wire (as small as possible).

*With a constant deflection (as before) successive dilutions of the sulphate of copper reduce the value of the deflection, but ~~the~~ a slight current continues to pass (2) with only a trace of sulphate in water, the deflection remaining constant.

K/PP107/2/3/57
Notes on the use of copper electrodes by Richard William Mellingford Higgs, chemist, [1871-1872] Feb 29.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

58

- Dec. 19th 72 -

The necessary precautions to be observed in order to approximate a constant cell, composed of zinc amalgam, copper, and sulphate of copper.

The Rheostat.

Before commencing experiments, the springs, attached to the binding screws & pressing against the axis of the cylinder of the Rheostat, should be thoroughly cleaned from oil & dirt, which causes the Galvanometer needle to be unsteady in its movements.

Zinc Amalgam.

The inconstancy of a cell was invariably found to be in the porous pot; & on investigation, the following were some of the defects to be eliminated.

The quantity of zinc in the amalgam does materially affect the electromotive-force. If constancy is required, the amalgam must be concentrated & always have in it a piece of zinc to keep the mercury at the same point of saturation. When really saturated the smallest quantity of amalgam in the porous cell will give as high an electromotive force as when full.

The most necessary precaution, is to see that the amalgam is quite free from dirt, black deposit? (which accumulates, either from shaking? or else from the dirt & impurities in the zinc dissolved) which ~~[illegible]~~ thickly forms on the sides of the porous pots during action and adheres to the $ZnSO_4$ and greatly decreases the electromotive-force.

Pure Mercury.

When opposing a zinc amalgam + copper cell ~~and~~ with a pure mercury + copper cell, it is necessary to ascertain whether the mercury is "positive" or "negative" to the copper.

K/PP107/2/3/58

Paper outlining precautions to be observed with regard to the rheostat, zinc amalgams, porous pot and sulphate of copper by John Rymer Jones (1851-[1919]), chemist and electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones, King's College London), 1872 Dec 19, page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

58

2. — Decr. 19th 72 —

— for it often happens that the current will, with two different samples of the so-called pure (?) mercury; in the one case deflect the Galv: needle to the right, & with the other samples as far to the left, or even make the needle deflect first to the right & then take up a constant deflection to the left. In which case, the mercury seems to have absorbed some impurity, for instance Sodium &c, from the air, thus acquiring a higher Electromotive-force than mercury really possesses.

Porous Pot.

The thickness of the porous pot does not alter in the least the Electromotive-force of a cell, provided the porous pot is thoroughly moist throughout, a circumstance which clearly shows that the internal resistance does not alter the Electromotive-force. The porous pots should be soaked in Nitric acid as seldom as possible, as it is difficult to get rid of every trace of it, unless which is done, the Electromotive force is altered by the mercury being acted on. When, however, they have been soaked in Nitric acid, they should be allowed to boil in clean water for some time, which will thoroughly wash them.

Sulphate of Copper.

The Sulphate should be saturated, else the copper is all soon thrown down & the copper plate becomes polarized, causing the Electromotive force to falls. A cell with H_2SO_4, but similar in other respects, has a weaker Electromotive-force than a cell with $CuSO_4$, being in the proportion of 110 ($CuSO_4$ cell) : 101 (H_2SO_4 cell) when first set up & rapidly falling as the polarization increases.

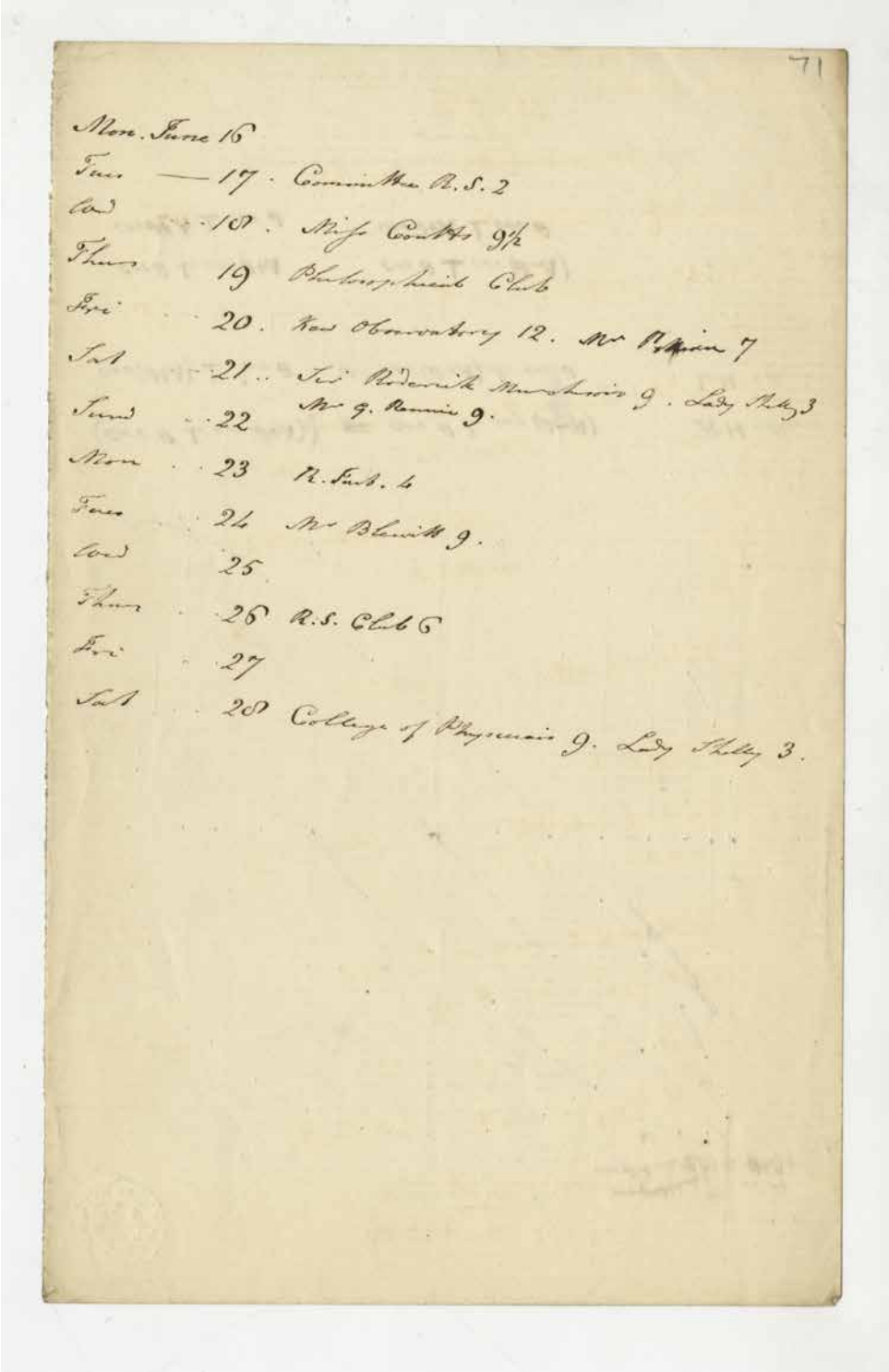
J. Rymer-Jones.

K/PP107/2/3/58

Paper outlining precautions to be observed with regard to the rheostat, zinc amalgams, porous pot and sulphate of copper by John Rymer Jones (1851-[1919]), chemist and electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones, King's College London), 1872 Dec 19, page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



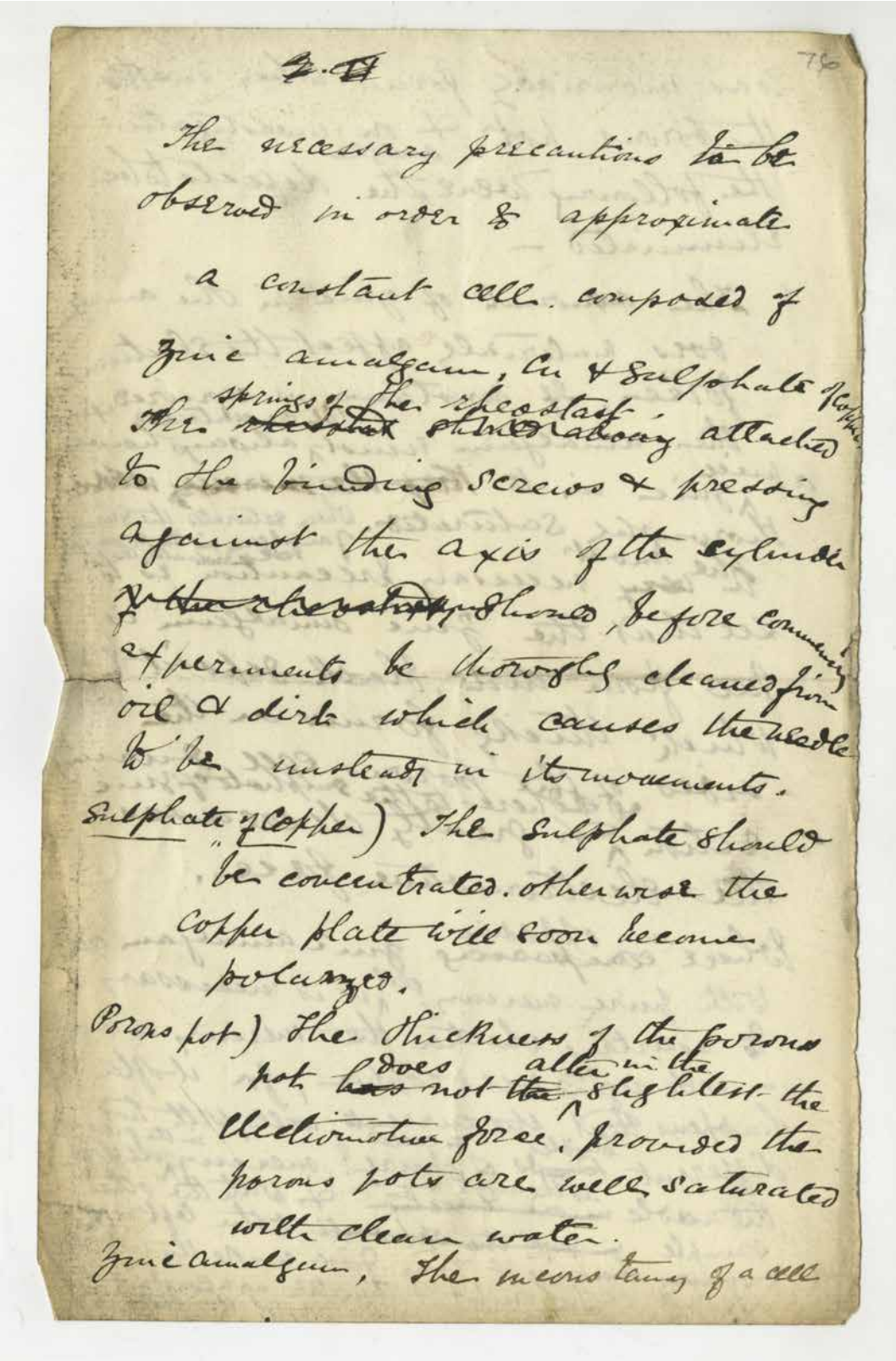
71

Mon. June 16
Tues — 17. Committee R.S. 2
Wed 18. Mins Coutts 9½
Thurs 19 Philosophical Club
Fri 20. Kew Observatory 12. Mr Playfair 7
Sat 21. Sir Roderick Murchison 9. Lady Shelley 3
Sund 22 Mr G. Rennie 9.
Mon 23 R. Inst. 4
Tues 24 Mr Blewitt 9.
Wed 25
Thurs 26 R.S. Club 6
Fri 27
Sat 28 College of Physicians 9. Lady Shelley 3.

K/PP107/2/3/71
List of meetings or appointments from Monday June 16 to Saturday June 28 1873.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



76

The necessary precautions to be observed in order to approximate a constant cell. composed of Zinc amalgam, Cu & Sulphate of Copper

The springs of the rheostat ~~[illegible]~~ ~~[illegible]~~ ~~[illegible]~~ ~~[illegible]~~ attached to the binding screws & pressing against the axis of the cylinder ~~[illegible]~~ should, before commencing experiments be thoroughly cleaned from oil & dirt which causes the needle to be unsteady in its movements.

Sulphate of Copper) The sulphate should be concentrated. otherwise the copper plate will soon become polarized.

Porous pot) The thickness of the porous pot ~~has~~ does not ~~the~~ alter in the slightest the electromotive force. provided the porous pots are well saturated with clean water.

Zinc amalgam, The mercurising of a cell

K/PP107/2/3/76

Draft of paper on precautions to be observed written by John Rymer Jones (1851-[1919]), electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones (1810-1880) at King's College London), [1872], page 1. See also K/PP107/2/3/58.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

was invariably found to be in the porous pot. & on investigation the following were some of the defects to be eliminated –

The amount of zinc in the amalgam does materially affect the electromotive force. If constancy is required & the amalgam must be concentrated & always have a piece of zinc in it to ~~keep the mercury also~~ thoroughly saturated. When saturated the zinc will amalgam in the porous cell after the first time.

The ~~very~~ most necessary precaution is to see that the zinc amalgam is free from dirt. Black deposit which thickly forms on the sides of the porous cell during action & greatly decreases the electromotive force, adheres to the sulphate of zinc.

Where ~~comparing~~ opposing zinc amalgam cell with pure mercury cell it is necessary to ascertain whether the mercury is + or – with regard to the copper, for it often happens that the currents, will, with two different ~~kinds~~ samples of so called pure mercury, in the one case deflect the needle ~~in one direction~~ to the right & with the other sample ~~in the opposite~~ to the left. ~~The mercury having~~ & some first make the needle deflect to the right & then take up a constant deflection to the left.

K/PP107/2/3/76

Draft of paper on precautions to be observed written by John Rymer Jones (1851-[1919]), electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones (1810-1880) at King's College London), [1872], page 2. See also K/PP107/2/3/58.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

77

when in which case the mercury seems to have ~~taken up~~ absorbed some impurity as Sodium for instance, from the air & thus have acquired a higher electromotive force than the pure mercury possesses.

A cell with H_2SO_4 ~~mixed of $CuSO_4$~~ has given a weaker Electromotive force than a cell with as $CuSO_4$ being in the proportion of 110 to 101 when first set up & falling rapidly as the polarization increases.

The cells should be soaked in Nitric acid as seldom as possible as it is difficult to get rid of every trace unless which is done the electromotive force is altered by the mercury being acted on. When however they have been impregnated with nitric acid, they should be ~~allowed~~ to ~~soak~~ in clean water for some time

Draft of paper on precautions to be observed written by John Rymer Jones (1851-[1919]), electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones (1810-1880) at King's College London), [1872], page 3. See also K/PP107/2/3/58.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

87

In all aqueous solutions water is the only substance immediately decomposed by the electric current: All other decompositions are secondary and are due to the ordinary chemical action of the evolved oxygen and hydrogen.

Thus in an element { amalgam of zinc / sult of copper / copper } the oxygen seizes on the zinc and converts it into an oxide, the hydrogen reduces the copper by combining with the oxygen of the oxide of copper and forming water, and the sulphate of the salt of copper combines with the zinc and forms sulphate of zinc. ~~Since~~ As the hydrogen is all consumed in the reduction of the copper no gas remains adhering to the copper plate and consequently no polarization takes place; this is the case when the metal is reduced in the perfect regulinic form.

The same takes place when any other metallic salt is reduced.

That the evolved hydrogen is necessary for the reduction of the metal, and that the metallic salt is not immediately decomposed by the current, can be proved by a very simple experiment. Fig 1 represents a cell of ebonite or any other insulating material divided by a porous partition; one compartment is filled with amalgam of zinc, and the other with

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

a solution of sulphate of copper; an insulating axis placed at right angles to the sides of the cell and partition carries a circular platinum plate which dips into the sulphate of copper, and by means of a pulley placed on the same axis connecting it with a rotary apparatus this plate may be put into rapid circular motion; while in motion it passes between the two slaps of a cloth or rubber which presses against the sides and clears it of any adherent gas or other adventitious matter. This apparatus being first set in rapid motion and the circuit then completed by the wires a ~~it will be seen~~ the evolved hydrogen will be cleared away before it has time to ~~act upon it~~ reduce the copper; the plate will therefore remain perfectly clean and no copper will be found on the rubber. Thus long the action may be continued no copper will appear, but if the platinum plate be allowed to rest even for a second or two all that portion of it immersed in the sulphate will be covered with the reduced copper.

Instead of the platinum plate being the negative electrode of a voltaic element, as in the preceding experiment, it may be the electrode of a decomposing cell, ~~but~~ placed in a circuit with a voltaic battery. For this case the same cells as before may be employed, but both compartments are to be filled by the solution of

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

88

Atomic Weights divided by Atomicities

Monads

Hydrogen	1
Fluorine	19
Chlorine	35.5
Bromine	80.
Cæsium	133
Rubidium	85.5
Potassium	39.
Sodium	23
Lithium	7
Thallium	204
Silver	108

Dyads

Oxygen	8
Barium	63.5
Strontium	43.7
Calcium	20.
Magnesium	12.
Zinc	32.5
Didymium	48.
Lanthanum	46.
Yttrium	34
Glucinum	7
Cadmium	56
Mercury	100
Copper	36.5

Triads

Boron	3.6
Gold	65.5

Tetrads

Carbon	3
Silicon	7.1
Tin	29.5
Titanium	
Thorium	57.8
Niobium	24.4
Tantalum	34.3
Zirconium	22.5
Aluminium	6.8
Platinum	49.3
Palladium	26.6
Lead	51.7

Pentads

Nitrogen	2.8
Phosphorus	6.2
Arsenic	15.
Antimony	24.4
Bismuth	41.6

Hexads

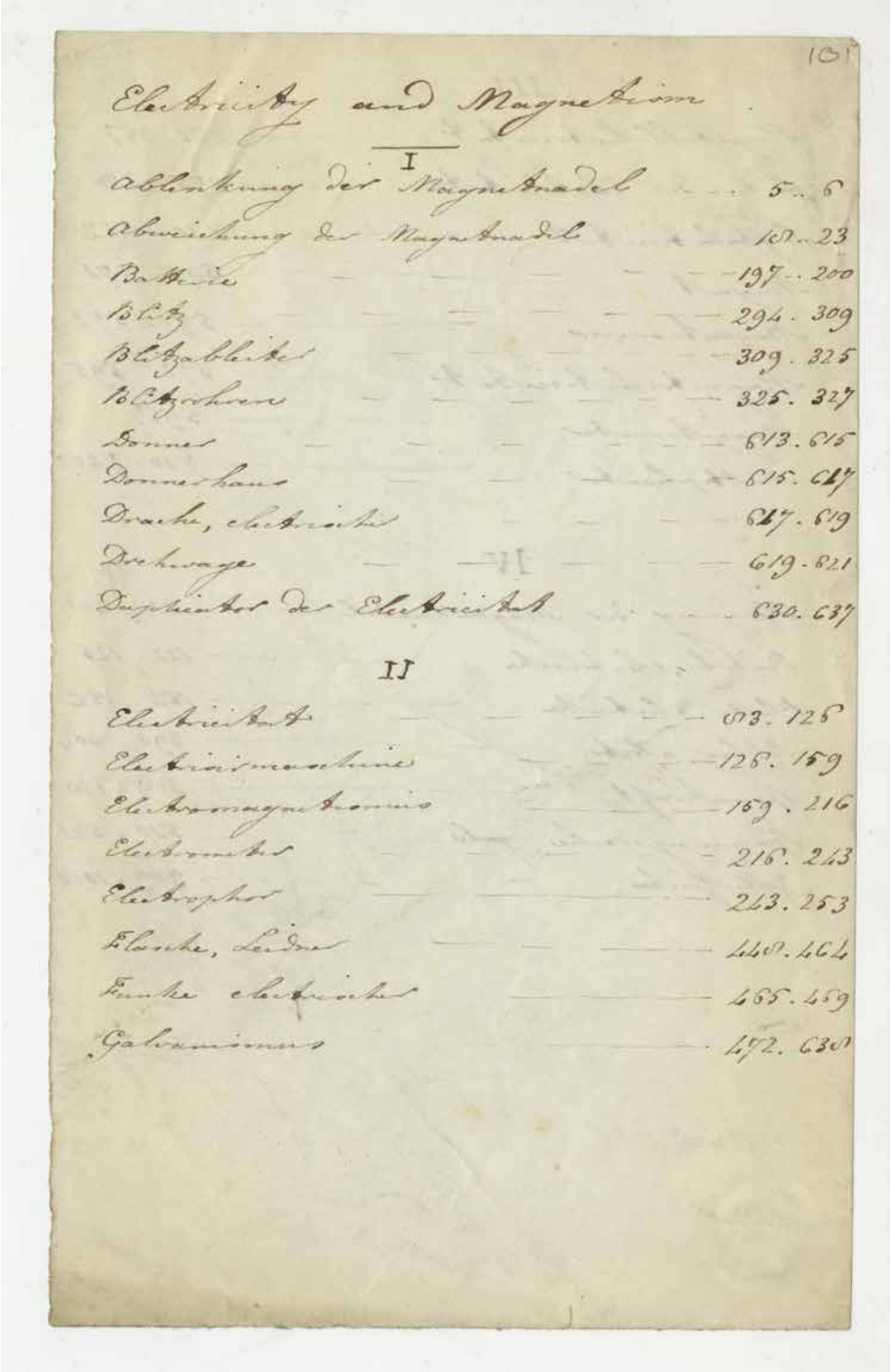
Sulphur	5.3
Selenium	13.1
Tellurium	21.3
Tungsten	30.6
Vanadium	22.8
Molybdenum	15.3
Osmium	33.1
Iridium	33.
Ruthenium	17.3
Rhodium	17.3
Chromium	8.6
Manganese	9.1
Iron	9.3
Cobalt	9.6
Nickel	9.6
Uranium	29
Cerium	15

K/PP107/2/3/88

Table of elements and their atomic weights, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



101

Electricity and Magnetism.

I

Ablenkung der Magnetnadel — 5. 6
Abweichung der Magnetnadel — 18. 23
Batterie — 197. 200
Blitz — 294. 309
Blitzableiter — 309. 325
Blitzröhren — 325. 327
Donner — 613. 615
Donnerhaus — 615. 617
Drache, electrischer — 617. 619
Drehwage — 619. 621
Doppelnatur der Electricität — 630. 637

II

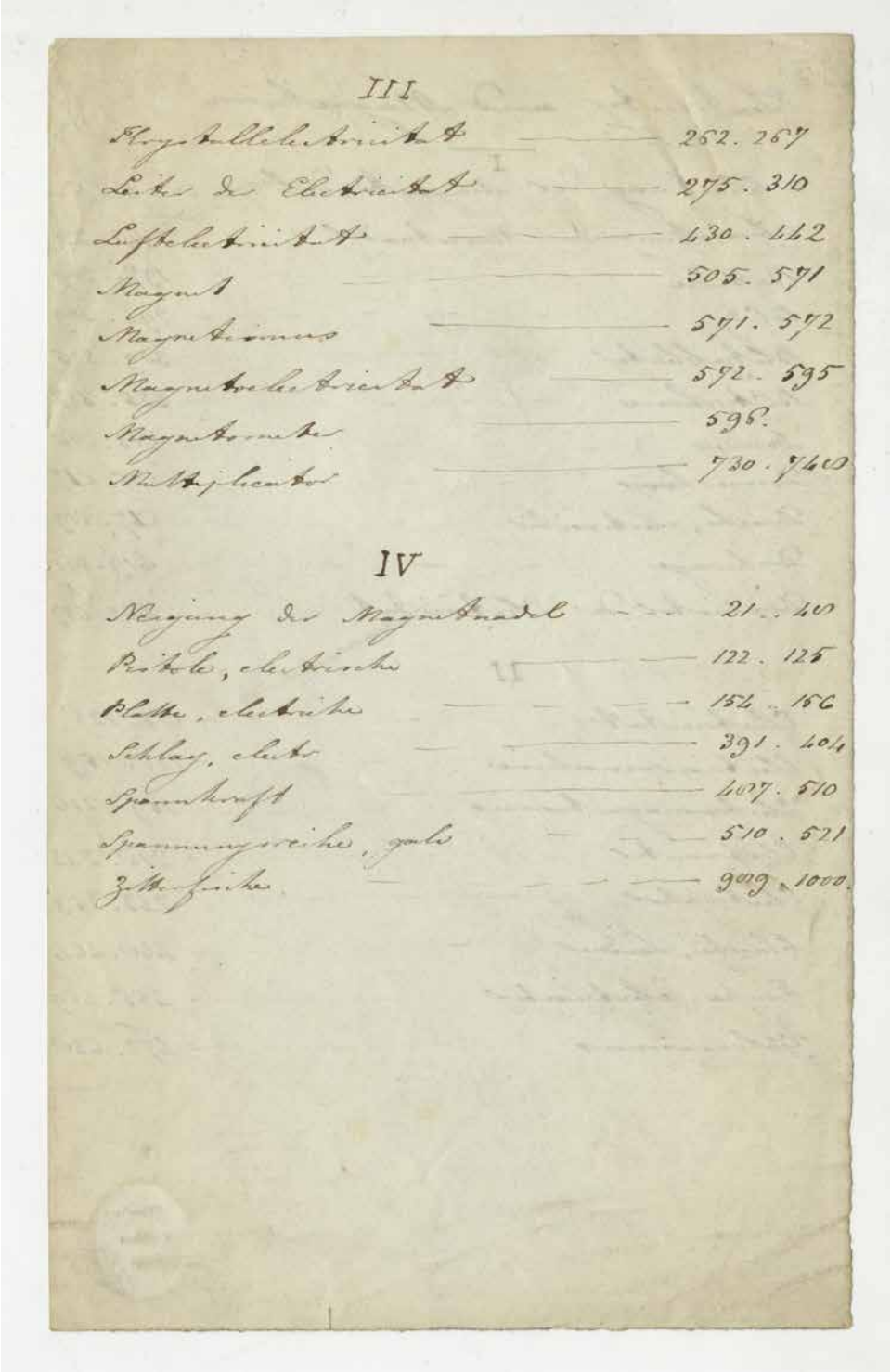
Electricität — 93. 125
Electrisirmaschine — 125. 159
Electromagnetismus — 159. 216
Electrometer — 216. 243
Electrophor — 243. 253
Flasche, Leider — 440. 464
Funke electrischer — 455. 459
Galvanismus — 472. 630

K/PP107/2/3/101

List of German terms relating to electricity and magnetism, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



III

Flugballelectricität — 252. 267
Leiter der Electricität — 275. 310
Luftelectricität — 430. 442
Magnet — 505. 571
Magnetismus — 571. 572
Magnetelectricität — 572. 595
Magnetometer — 596.
Multiplicator — 730. 740

IV

Neigung der Magnetnadel — 21. 40
Pistole, electrische — 122. 125
Platte, electrische — 154. 156
Schlag, electr — 391. 404
Spannkraft — 407. 510
Spannungsreihe, galv — 510. 521
Zitterfische — 909. 1000.

K/PP107/2/3/101
List of German terms relating to electricity and magnetism, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

102

	Rubidium	Sodium	Strontium	Ammonium	Cæsium	Potassium
Sodium	+ 15.3	0.0	13.5	(16.3)	15.9	21.5
Potassium	30.1	+ 21.5	+ 7.3	+ 5.2	+ 5.2	0.0
Zinc	133.3	116.9	103.1	100.0	100.0	+ 95.0
Copper	233.3	216.9	203.3	200.0	200.0	195.0
Platinum	265.5	249.6	236.1	232.6	232.9	227.7
per ce Lead	359.7	343.4	329.8	327.6	326.3	321.1

	Barium	Magnesium	Yttrium	Lithium	Silicium	Calcium
Sodium	25.3	29.6	50.0	76.3	76.3	83.3
Potassium	1.6	27.7	27.7	54.8	55.2	61.8
Zinc	+ 93.0	+ 66.6	+ 66.6	+ 39.9	+ 39.9	+ 32.9
Copper	193.3	166.6	166.6	139.9	140.0	133.3
Platinum	226.4	199.6	200.0	172.9	172.9	165.9
per ce Lead	319.4	293.4	293.4	266.6	266.0	259.7

	Zirconium	Beryllium	Manganese	Iron	Zinc	Uranium
Sodium	91.6	106.9	111.1	111.8	116.9	123.6
Potassium	69.4	85.0	89.9	90.9	(95.4)	102.7
Zinc	+ 25.0	+ 9.7	+ 5.2	+ 4.1	0.0	6.9
Copper	125.0	110.0	104.8	104.1	+ 100.0	+ 91.9
Platinum	157.9	142.3	130.1	137.1	132.9	125.0
per ce Lead	251.7	236.1	231.5	230.9	226.7	218.7

	Titanium	Iron	Molybdenum	Tin	Lead	Cadmium
Sodium	120.1	133.3	151.0	154.5	158.3	159.3
Potassium		111.6	129.5	132.9	136.6	137.8
Zinc	11.4	16.6	34.7	38.1	41.6	43.1
Copper	+ 88.5	+ 83.3	+ 64.9	+ 62.1	+ 58.3	+ 57.2
Platinum	121.5	116.3	98.2	94.7	91.6	89.9
per ce Lead	215.2	210.0	192.0	188.5	185.0	183.6

K/PP107/2/3/102

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

102

	Tungsten	Thallium	Vanadium	Bismuth	Mercury	Cobalt
Sodium	161.4	166.6	175.6	183.3	192.7	193.0
Potassium	139.9	144.4	153.8	161.6	171.1	172.9
Zinc	45.1 +	49.6 +	59.0 +	66.6 +	76.3 +	78.1 +
Copper	54.8	50.3	40.6	32.6	23.9	22.5
Platinum	87.8	83.3	73.9	66.6	56.5	54.4
per ox Lead.	181.5	177.1	167.3	160.4	151.0	149.6

	Chromium	Nickel	Arsenic	Antimony	Aluminum	Copper
Sodium	193.7	203.4	210.0	210.8	214.9	216.9
Potassium	172.9	181.8	188.8	189.0	193.	195.0
Zinc	78.1 +	86.8 +	93.7 +	93.6 +	98.2 +	100.0
Copper	22.5	13.1	6.2	6.0	34.6	0.0 +
Platinum	53.8	46.6	39.2	39.9	34.7	32.9
per ox Lead	148.2	139.5	132.9	132.6	128.4	126.7

	Tellurium	Osmium	Ruthenium	Silver	Rhodium
Sodium	233.3	237.8	237.8	239.9	244.7
Potassium	211.4	216.3	216.3	218.4	223.2
Zinc	116.6	121.5	121.5	123.2	128.4
Copper	17.0 +	21.1 +	21.5 +	22.9 +	28.4 +
Platinum		11.8	11.1	10.6	2.1
per ox Lead	110.7	104.8	105.2	103.4	98.7

	Platinum	Palladium	Gold	Iridium
Sodium	249.3	250.0	255.5	255.2
Potassium	227.7	227.7	233.8	233.8
Zinc	133.3	132.9	138.8	138.8
Copper	33.0	33.3	38.0	39.9
Platinum	0.0 +	0.0 +		
per ox Lead	93.7	93.4	88.5 + 2.1	87.6 + 2.1

K/PP107/2/3/102

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

	Sodium	Ammonium	Potassium	Magnesium	Lithium	Barium	Strontium
Sodium	0.0	(153)	21.5	49.6	76.3	57.2	111.0
Potassium	21.5	5.2	0.0	27.7	54.0	34.7	90.9
Zinc	116.9	100.0	95.0	66.6	39.9	(60.0)	4.18
Copper	216.9	(200.0)	(195.0)	166.6	139.9	160.	104.1
Platinum	249.6	232.6	227.7	199.6	172.9		137.1
per ex Lead	343.4	327.6	321.1	293.4	266.6		230.9

	Manganese	Zinc	Uranium	Iron	Tin	Lead	Cadmium
Sodium	111.1	118.9	123.6	133.3	154.0	150.3	159.3
Potassium	89.9	(96.9)	102.7	111.6	132.9	138.6	137.0
Zinc	5.2	0.0	6.9	18.6	30.1	41.6	43.1
Copper	104.0	100.0	91.9	83.3	62.1	50.3	57.2
Platinum	130.1	132.9	125.0	116.3	93.7	91.6	89.9
per ex Lead	231.5	225.7	210.7	210.0	187.5	185.0	183.6

	Thallium	Bismuth	Mercury	Cobalt	Chromium	Nickel	Antimony	Arsenic
Sodium	188.6	182.5	183.0	193.0	193.7	203.4	210.0	210.0
Potassium	124.4	181.6	171.1	172.9	172.9	187.0	189.0	190.0
Zinc	29.6	66.6	76.3	70.1	70.1	86.0	94.0	93.7
Copper	50.3	32.6	23.9	22.5	22.5	13.1	6	
Platinum	83.3	65.6	56.5	54.4	53.0	46.5	39.9	
per Lead	177.1	160.4	170.0	149.5		139.5	131.9	132.9

	Aluminium	Copper	Tellurium	Silver	Platinum	Palladium	Gold	Iridium
Sodium	211.0	216.9	233.3	239.9	249.3	250.0	255.5	255.2
Potassium	193.0	196.	211.4	210.4	227.7	227.7	233.0	233.0
Zinc	90.6	100.	111.1	123.2	133.3	132.9	130.0	130.0
Copper	92.0	0.0	17.0	22.9	(33.0)		30.0	39.9
Platinum	35.2	32.9	9.3	10.6	0.0		5.2	6.2
per Lead	131.9	126.7	110.7	103.4	93.7	93.4	90.1	87.1

K/PP107/2/3/103

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 3.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

	Rubidium	Strontium	Cæsium	Barium	Yttrium	Beryllium
Sodium	16.3	13.5	15.9	25.3	50.0	106.9
Potassium	30.1					
Zinc	133.3	103.1	100.0	93.0	66.6	9.7
Copper	233.3	203.3	200.0	193.3	166.6	110.0
Platinum	265.6	236.1	232.9	226.4	200.0	142.3
po Lead	359.7	329.0	326.3	319.4	293.4	236.1

Sd 0. Ca 15.0 Pt 21.5 Mg 49.5 Ln 96.3 Sodium 110.0

	Calcium	Titanium		TO_2	Ruthenium	Molybdenum	Rhodium
Sodium	83.3	127.0	120.1	TO 104.1	237.0	151.0	244.7
Potassium	61.0			TO_2 196.3	216.3		223.2
Zinc	32.9	11.4	11.1		121.5	34.7	120.4
Copper	133.3	88.5	00.5			64.9	
Platinum	165.9	121.5	120.0			95.9	
po Lead	259.7		215.2			192.0	97.9

Rubidium	82.7
Sodium	100.0
Strontium	113.5
Ammonium	115.0
Cæsium	115.9
Potassium	121.5
Barium	125.3
~~Titanium~~	~~127.0~~
Magnesium	149.6
Yttrium	150.0
Calcium	103.3
Beryllium	206.9
Sodium	211.0
Manganese	211.9
Zinc	216.9
Titanium	227.0

Tungsten

Sodium	161.4
Potassium	139.9
Zinc	45.1
Copper	54.0
Platinum	87.0
po Lead	101.5

K/PP107/2/3/103

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 4.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

104

	Thorinum	Cerium	Niobium	Lanthanum	Didymium
Sodium	46.5	64.5	171.8	60.7	71.1
Potassium	25.6	42.7	150.3	39.2	49.6
Zinc	69.4	52.0	55.5	55.5	45.2
Copper	169.0	152.0	44.4	155.5	145.2
Platinum	202.4	184.7	77.0	188.1	177.7
per ox Lead	296.1		171.1	281.9	271.8

	Tantalum	Amorphous Boron	Graphitoid Boron	Carbon
Sodium	179.1	98.6	237.8	233.3
Potassium	157.6	76.3	216.3	
Zinc	62.8	18.0	121.5	116.6
Copper	36.4	118.0	21.5	
Platinum	70.4	151.0	11.1	
per ox Lead	163.8	247.7	104.8	

K/PP107/2/3/104

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 5.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

	Hydrogenized Platinum
Sodium	182.2
Potassium	180.7
Zinc	65.9
Copper	33.6
Platinum	66.6
per ox Lead	159.7
	102.80

K/PP107/2/3/104

Table of chemical elements and figures relating to their amalgamation with sodium, potassium, zinc, copper, platinum and lead, [1871-1873], page 6.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

105

April 21. 1872

Pure Mercury placed in a porous pot which had been for some time kept in common water, was made into a circuit with dilute sulphuric acid and copper. The needle deviated only a few degrees the mercury being in general negative. But when a porous pot filled with mercury was dried by placing it close to the fire, or when cold mercury was placed in a dried porous pot, and then put in the circuit the needle deflected strongly and the E.M.F was 39 (S. 127) mercury being partly negative. The E.M.F between am Zinc and Mercury was 156.

The am Zinc seems also to be affected the E.M.F with Sol Cop and Copper was 100 when a dry porous pot was employed, 127 when a wet pot was employed.

It results that the dry porous renders the amalgam more negative; it therefore increases the E.M.F of a negatived metal and decreases that of the positive metal. Which is the real E.M.F that with the dry or that with the wet porous pot.

K/PP107/2/3/105

Notes describing an experiment to determine the electromotive force of zinc and mercury, 1872 Apr 21.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

108

Circumstances that may influence the accuracy of the measure.

1 ~~The~~ If the resistance of the circuit changes while the measure is being taken the measure will be inaccurate. The needle should remain steady at the two limits before and after the measure is taken.

2 Imperfect contacts in the springs of the shunt and in the parts of the circuit will increase the resistance of the circuit, and if these contacts should be variable and occur while the measure is being taken the measure will be affected.

3 ~~If~~ The magnetic force of the needle should be subject to change, a measure made at one time will not accord with a measure made at another time. But it will be easy to compare every new measure with a measure made with the standard element.

K/PP107/2/3/108

Notes on the circumstances that may influence the accuracy of measurements, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

129

July 8th 1872.

Sir Charles Wheatstone, F.R.S.,

My dear Sir,

I post you the list of amalgams with references to page of Gmelin's Handbook and directions. The article in last week's "Chemical News" I have put into Mr. Jones' hands. Mr Jones visited me Friday evening and we chatted about the various methods in use in your laboratory.

I am,
My dear Sir,
Yours truly & obediently,
R. William Higgs.

K/PP107/2/3/129

Letter from Richard William Mellingford Higgs largely regarding John Rymer Jones (1851-[1919]), chemist and later electrical engineer at the India Rubber Gutta Percha and Telegraph Works (son of Thomas Rymer Jones (1810-1880), Professor at King's College London), 1872 Jul 8.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

130

July 5th 1872.

Sir Charles Wheatstone, F.R.S
&c &c.

My dear Sir,

Analysis of the acid solution obtained in the purification of the mercury gives the following results:-

Found:

Copper (in quantity).
Mercury (do.).
Iron (in small quantity).
Lead
Zinc
Cadmium
Cobalt
? Nickel
} (traces only).

Not found:

Bismuth, Chromium, Platinum, Palladium, nor any of the Alkali-metals.

Remarks:

The spectrum is very complex; and successive elimination is too difficult to give satisfactory spectra. The appearance of nickel is questionable.

From the excess of copper (from the negative plate) there may be a reflex action (since copper is electro-positive to Mercury)

resulting in the formation of a very dilute copper amalgam instead of pure mercury. Ordinary tests for copper do not, however, show this. But perhaps it would be better to repurify the mercury employing instead of copper a platinum plate in the sulphuric acid.

I am,

My dear Sir,

Truly and Obediently

Yours,

R. William Higgs

To Sir Charles Wheatstone, F.R.S., &c.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

131

5, Cornwall Road
Hammersmith, W.
July 3rd. 1872.

Sir Charles Wheatstone, F.R.S.,

My dear Sir,

After leaving you this morning I saw Mr. Jones. He is I find a very good chemist. Permit me to suggest that if he were with me on Thursday a portion of the day I might instruct him in several of your processes. I am preparing a series of instructions for your future assistant, but of course there are many practical points that it is very difficult to express in so many words. I shall however be pleased at any time to call upon you and state my

K/PP107/2/3/131

Letter from Richard William Mellingford Higgs regarding John Rymer Jones (1851-[1919]), chemist and later electrical engineer at India Rubber and Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones, King's College London), 1872 Jul 3, page 1.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

experience and illustrate, should it be required. I must ask you to take a decisive step in providing yourself with further and more reliable assistance, as I have arranged presently to be out of town; indeed I am only awaiting your pleasure.

I am

My dear Sir

truly & obediently Yours,

William Higgs

Sir Charles Wheatstone F.R.S., &c. &c.

K/PP107/2/3/131

Letter from Richard William Mellingford Higgs regarding John Rymer Jones (1851-[1919]), chemist and later electrical engineer at India Rubber and Gutta Percha and Telegraph Works (son of Professor Thomas Rymer Jones, King's College London), 1872 Jul 3, page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

Therms-Electricity 145

1st Hypothesis.

1 An electro-motive exists at the contact of any two metals

2 This electromotive force differs with the temperature.

3 In a circuit formed of two metals heat at the same temperature, the currents must be in opposite directions at the alternate joints; and as they are equal they must neutralize each other.

4 But if the alternate joints are kept at two different temperatures, the sum of the electro-motive forces in one direction will no longer be equal to the sum of the electro-motive forces in the opposite direction, and a current the difference of the two will be rendered manifest.

5 If the circuit consist of three or more metals ~~any~~, since at all temperatures equilibrium results it is necessary to admit not only that the ~~—~~ electro-motive force of two distant metals is equal to the sum of all the intermediate couples, but the same augmentation of temperature produces a proportionate augmentation of the electro-motive force.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

Consequences of the 1st hypothesis:

1 The order of the electro-motive forces according to Volta, or the order of the voltaic series, should correspond with the thermo-electric series. But this is not the case.

2. The same increase of temperature should produce a greater increase of effect according as the electro-motive force due to contact is greater. Zinc and Platinum for instance should produce a more powerful current than Bismuth & Antimony; but the contrary is the case.

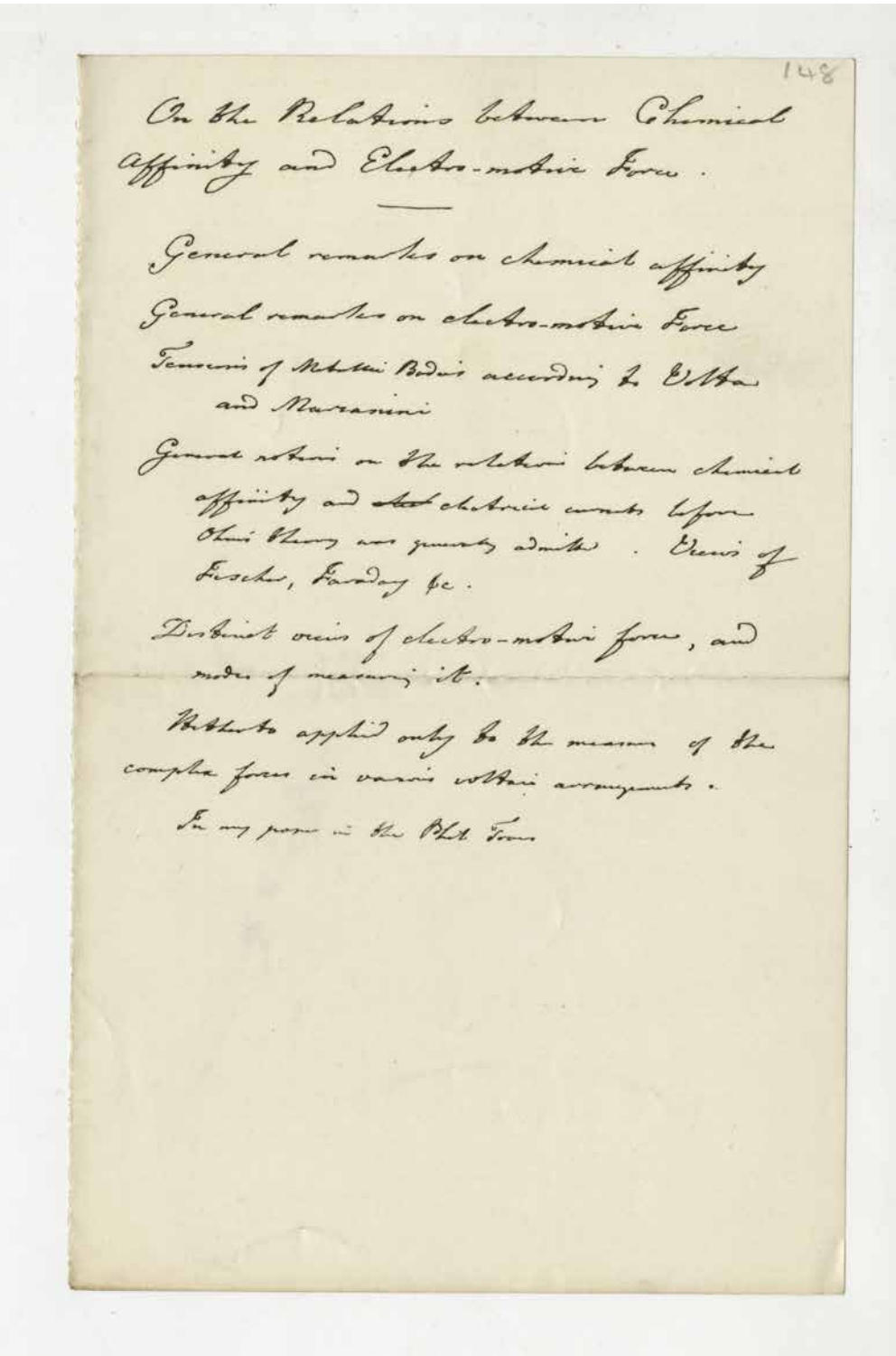
3. The application ~~augmentation~~ continually increased of temperature to one set of joints should always increase the thermo-electric current, but Cumming and Becquerel have shown that in certain circuits the current at first augments and then decreases even to zero.

K/PP107/2/3/145

Notes on hypotheses relating to thermo-electricity, [1871-1873], page 2.

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph



148

On the Relations between Chemical Affinity and Electro-motive Force.

General remarks on chemical affinity

General remarks on electro-motive Force

Tensions of Metallic Bodies according to Volta and Marianini

General notions on the relations between chemical affinity and ~~elect~~ electric currents before Ohm's theory was generally admitted. Views of Fischer, Faraday &c.

Distinct views of electro-motive force, and modes of measuring it.

Methods applied only to the measure of the complex force in various voltaic arrangements.

See my paper in the Phil. Trans.

K/PP107/2/3/148

Notes on the relation between chemical affinity and electromotive force, [1871-1873].

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

149

A very important question to be determined is whether a certain definite amount of electro-motive force is required to overcome the affinity of each electrolyte as Faraday and others have supposed, or whether the resistance to decomposition arises solely from the contrary electro-motive force generated by the action of the current. The following experiments will prove that when the polarization, the result of decomposition, are removed, the liquid conducts as an ordinary conductor and that the decomposition which the current effects is in exact proportion to the strength of the current.

When a voltameter has been interposed for a short time in a circuit with one or two platinum plates, there is no development of gases and unless a very delicate galvanometer be employed there is no evidence of current. If however the attention be directed immediately after the completion of the circuit, it will be found that gases are generated and that the galvanometer shows a considerable amount of current for a moment until the development of gases ceases.

Employing the decomposing cell with rotating electrodes fig x by which the gases are removed as soon as formed, polarization is prevented, and the current of a single cell then passes readily through the circuit, and currents however small their emf may be will pass through

The Papers of Charles Wheatstone

K/PP107/2/3 - Papers relating to the development of the electric telegraph

it as they would ~~though~~ ~~as entirely~~ it were a metallic wire having the same resistance substituted for the liquid. X

Another method of avoiding polarization, and thereby permitting the electric action to be transmitted without impediment is to allow alternately induced currents to pass through the voltameter. But in this case a galvanometer cannot be employed to measure the effects; recourse must be had to Weber's dynamometer which instrument gives on the momentary of rapidly repeated induced currents, the index ~~is affected~~ moving in the same direction whether the currents be positive or negative.

and if the e m f of the circuit be measured, whether one, two or more cells are employed no contrary e m f will have to be deducted.