PUPIL
RESEARCHER
INITIATIVE

# Michael Faraday and Electrolysis

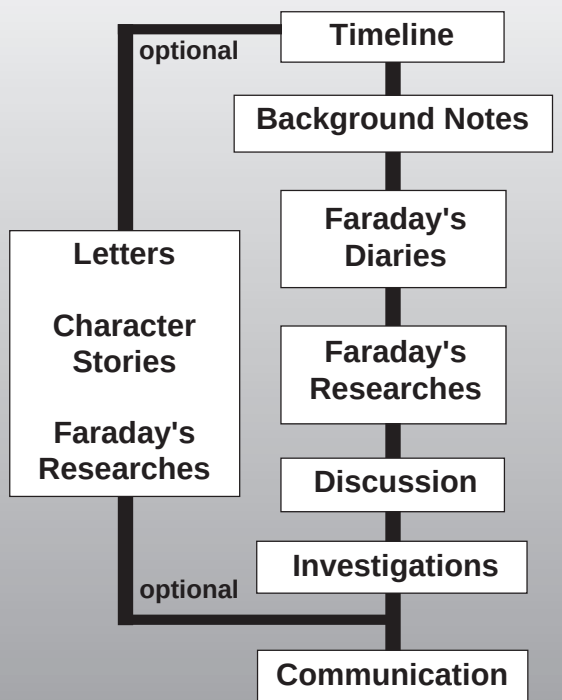
## Pupil Research Brief

## Study Guide

### Syllabus Coverage *Science you will learn about in this Brief*

- ❑ when substances which are made of ions are dissolved in water, or melted, they can be broken down into simpler substances by passing an electric current through them (electrolysis)
- ❑ during electrolysis, positively charged ions (eg., metal ions) move to the negative electrode, and negatively charged ions move to the positive electrode
- ❑ during electrolysis gases may be given off, or metals may be deposited at the electrodes
- ❑ at the negative electrode the positively charged ions gain electrons (reduction)
- ❑ at the positive electrode the negatively charged ions lose electrons (oxidation)

### Route through the Brief




### Outcome Checklist

Using extracts from Faraday's Diaries, Letters and Researches you will look at his working methods and take part in a discussion about his work. You will also carry out your own investigations into electroysis and compare his results with your own. You should make sure you produce the following items as you work through the Brief.

**Timeline and Background Notes**

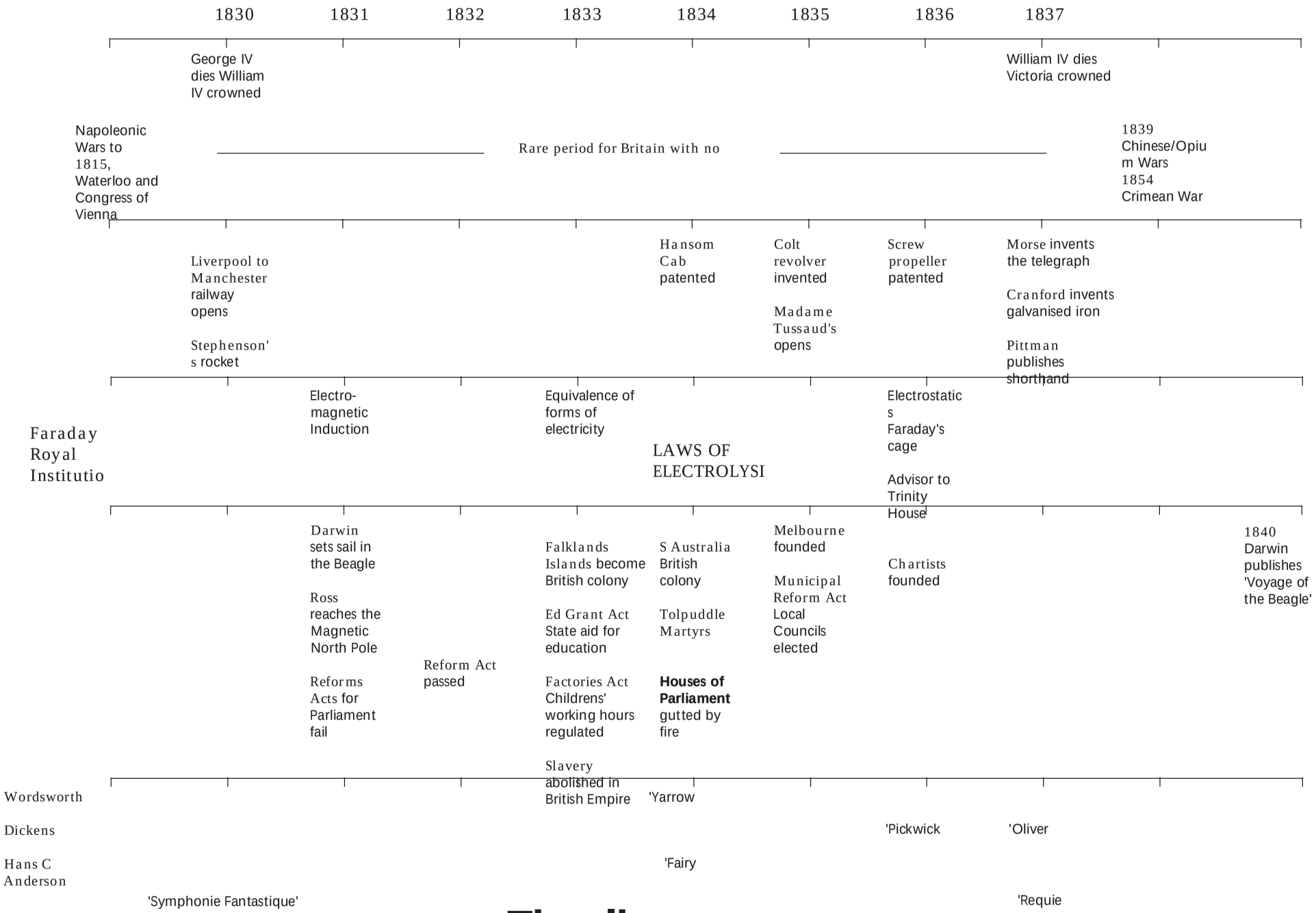
- ❑ brief summary notes based on the questions set by the teacher from the *Discussion Guidelines* sheet
- ❑ notes for a short presentation or poster display based on the relevant questions from the *Discussion Guidelines* sheet

**Diary and Researches material**

- ❑ brief notes based on your discussions, including answers to the questions on the *Discussion Guidelines* sheet

**Investigation Guidelines sheet**

- ❑ investigation report
- ❑ answers to questions raised on the *Investigation Guidelines* sheet


1830
1831
1832
1833
1834
1835
1836
1837
George IV dies William IV crowned
William IV dies Victoria crowned
Napoleonic Wars to 1815, Waterloo and Congress of Vienna
Rare period for Britain with no
1839 Chinese/Opium Wars
1854 Crimean War
Liverpool to Manchester railway opens
Stephenson's rocket
Hansom Cab patented
Colt revolver invented
Madame Tussaud's opens
Screw propeller patented
Morse invents the telegraph
Cranford invents galvanised iron
Pittman publishes shorthand
Faraday Royal Institutio
Electro-magnetic Induction
Equivalence of forms of electricity
LAWS OF ELECTROLYSI
Electrostatics Faraday's cage
Advisor to Trinity House
Darwin sets sail in the Beagle
Ross reaches the Magnetic North Pole
Reforms Acts for Parliament fail
Reform Act passed
Falklands Islands become British colony
Ed Grant Act State aid for education
Factories Act Childrens' working hours regulated
Slavery abolished in British Empire
S Australia British colony
Tolpuddle Martyrs
Houses of Parliament gutted by fire
Melbourne founded
Municipal Reform Act Local Councils elected
Chartists founded
1840 Darwin publishes 'Voyage of the Beagle'
Wordsworth
Dickens
Hans C Anderson
'Symphonie Fantastique'
'Yarrow
'Fairy
'Pickwick
'Oliver
'Requie

# Timeline

## Background Notes - Michael Faraday and Electrolysis

In your pairs or small groups read through the Background Notes and discuss and make notes on the following.

(a) How do you think the way science was conducted and people's attitudes to science has changed since Faraday's time?

(b) Why do you think the Royal Institution was such a popular place for people of all classes?

(c) How is 'popular' science presented today?

(d) Do you think enough is done to promote science? How could science be made more interesting and popular with the public?

(e) Trace out how Faraday became interested in science and how he managed to become a professional scientist.

(f) Explain the way that Faraday did his work and how he made the results of his researches available. How does this differ from the way this is done today?

(g) Explain Faraday's conclusions about the nature of electricity and its applications. What has been the impact of Faraday's discoveries about electricity?

(h) What are the modern applications of Faraday's use of electricity to decompose chemical solutions?

## Faraday's *Diary* extracts

In your pairs or small groups read through the diary extracts 606 through to 1846 and then do the following.

**For paragraphs 606/7**

(a) What was the investigation he was trying to set up in para 606?

(b) What results did he get in para 607 and what explanation did he give for the differences in the results?

(c) Briefly discuss how you would set up a simple electrolysis experiment to determine whether electrode size affects the electrolysis process.

**For paragraphs 1274/1275**

In this experiment Faraday was trying to determine whether changing the material from which one of the electrodes was made had any effect on the electrolysis. A complication arose because the zinc electrode reacts with sulphuric acid even when not attached to a battery.

Suggest another electrolysis experiment which would allow you to investigate the effect of changing one of the electrodes on the electrolysis process without this sort of complication arising.

**For paragraph 1846**

Faraday began an experiment but did not follow it through. What was this experiment? What results would you have predicted? (You may be doing this investigation later).

## Faraday's *Researches* extracts

In your pairs or small groups read through the Researches extracts and then do the following:

**For paragraphs 791 - 821**

What was Faraday trying to show with his experiment described in paras 791 - 792?

Do you think that his results give rise to 'an irresistible mass of evidence proving the truth'?

# Investigation Guidelines

You have already read and discussed some of Faraday's investigations into electrolysis. Now you will have a chance to check out some of his results and conclusions by doing your own investigations. Before you start check with the **Study Guide** to find out what you need to produce. Working in your team you can plan and carry out one or more experiments to investigate some of the factors which might affect the electrolysis process.

For example, like Faraday, you could investigate and present your conclusions on one or more of the following.

(i) Does the **size of the electrode** have any effect on electrolysis?

*Compare with Faraday's Diary Experiments (606/607) and the commentaries.*

(ii) Does the **amount of current** and/or the **time it passes for** have any effect on electrolysis?

*Refer back to Faraday's Researches (Expts. 791-821) and the commentaries.*

(iii) Does **varying the temperature of the electrolyte** have any effect on electrolysis? Note in *Faraday's Diary (Expt. 1846)* that although he suggested the experiment, he did not follow it up. You should try to design your own experiment, using modern apparatus to investigate the effect of varying the temperature.

(iv) Although Faraday's notes do not make any reference to whether **varying the distance between the electrodes** would affect electrolysis, perhaps you could try this.

(v) Try to identify and explain at least one **advantage** you had with your apparatus compared with Faraday.

A good experiment to try out the above investigations is the electrolysis of copper sulphate solution, using copper electrodes.

You will need to plan your investigation, decide upon the apparatus you will need and the experimental conditions, and then discuss this with your teacher.

**In planning your investigations think about:**

- the type of power supply and the suitable constant voltage level for running the electrolysis
- how you will measure the current flowing during electrolysis
- how you will ensure that the electrodes are clean
- what you can measure (and how you can ensure accuracy) to show how the factors you change affect electrolysis
- how you will ensure that you set up a fair test in each investigation
- how you can present your results in tables and graphs.

**Note: the quantity of electricity passing during electrolysis (coulombs) is equal to**

***current (amps) x time (seconds)***

**This will be useful when doing investigation (ii) and when considering Faraday's Law of Electrolysis, i.e. that 'chemical action or decomposing power is exactly proportional to the quantity of electricity". Think about how you could present your results in a graph to show this.**

Your team does not have to do all of these investigations. Other teams can do different ones and results and conclusions can then be presented to the whole class.

Faraday usually worked on his own and discussed his ideas and results with many other workers over a fairly long period of time. Nowadays, researchers usually work in teams, investigating different aspects of a problem. The teams may be based in the same department or in different departments of a university or industrial research organisation. Teamwork brings together a wide range of expertise. It enables different individuals and teams to tackle different parts of the problem or investigation and then to pool results. This often leads to quicker solutions and, where necessary, a more in-depth and detailed investigation.

Today, researchers are usually 'working against the clock' because of limited funds, short timescales and in some cases, competition between researchers working in the same field.

These are extracts from Faraday's own laboratory notebook, the originals of which are on display in Faraday's Museum at the Royal Institution.

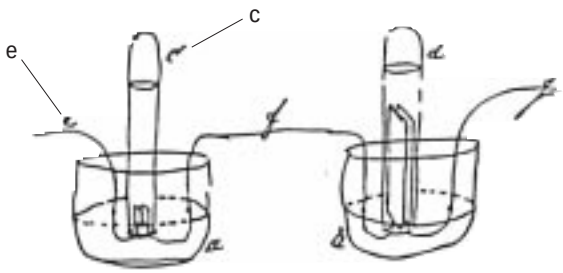
Vol. II Aug. 25, 1832 - Feb. 29, 1836

Edited by Thomas Martin
Published by the Royal Institution of Great Britain 1932
G. Bell and Sons, Ltd, London

31 AUG. 1833

606. Experimented on action (decomposing) of the same electric current on different aqueous solutions. The battery used consisted of four troughs or 40 plates 4 inches square and double coppers. It was not changed from first to last and at the end was much reduced in power. a and b were two finger basins, c and d two small gas jars , graduated. At first a, b, c and d contained a dilute Sul. acid of S.G. 1054; e is the wire of platina connected at pleasure with the Pos. Pole of battery and gold soldered at the end of the jar c to a small plate of platina 0.5 by 0.8 of an inch wide. A similar plate in the same jar was gold soldered to the end of a thick platina wire f which was at the other end soldered to a plate of platina 0.7 by 3.8 inches in length and breadth - a similar plate was gold-soldered to the platina wire g and this communicated with the neg. pole of the battery. So that there was a pair of small and a pair of large poles immersed in acid of the same strength, through each of which would proceed equal quantities of electricity. The acid was drawn off as far as could safely be done from the finger basins, to avoid decomposition as much as possible elsewhere than within and under the air jars.

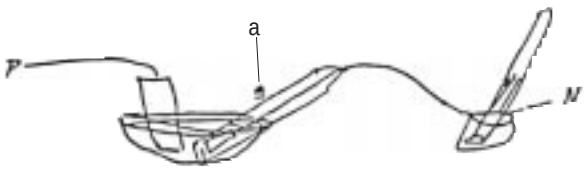
607. On making the battery contact, sufficient gas was evolved in less than half a minute to fill the jars nearly. On comparing their quantities there was 1.9 cubical inches in the jar c and 2.2 cubical inches in the jar d. The experiment was very beautiful and the approach to equality great. A sufficient reason for the difference was visible, for because of the smallness of the poles in the jar c the parts of the wires in the acid of the basin a gave out more gas than the similar parts of those in basin b, and hence a greater part of the decomposition was lost there.




27th DECR. 1833

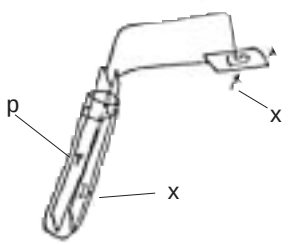
1274. Expts. to ascertain if varying the nature of the Electrode would vary the proportion of substance decomposed by the Electric current.

1275. Dilute Sul. Acid, about 1 oil vitriol to 3 water, so as to act strongly on Zinc, was put into a basin. An Electrode of Platina a in a tube filled with the same acid and inverted in the basin. The end of the wire was connected with a Volta electrometer and that with the Neg. end of a voltaic battery of 40 pr. of plates. A plate of Zinc was connected with the Positive end of the battery and plunged into the same acid. In this case the acid was so strong as to evolve plenty of hydrogen at the Zinc, both when out of contact and also **in contact** with the P.Pole of the battery. Yet this did not in the slightest degree disturb the proportion of water decomposed by the electric current, for the gas O. and H. in the Volta electrometer - 1.53 c:i: and that in the Neg. Electrode tube a = 1.04 c: i:, or just 2/3rds. It was of course the Hydrogen alone; the Oxygen had passed to the Zinc.




28 MAY 1834

1846. Expt. to try if heat would, by exalting chemical affinity, increase initial intensity of a current. A zinc amalgamated and platina plate separated by paper were put into hot dilute S.A. s.g. 1.25. The zinc was connected with a platina plate p on which was put a drop of Mr.



# Commentary

The quotes are taken from experiments that Faraday did over one year, August 1833 to May 1834. The words and style of language we use have changed over the years. Things like ammeters had not been invented then, and even the units used for measurements have changed since.

## 606 Size of Electrodes

*battery* — Remember there was no such thing as mains electricity. Indeed, Faraday did a great deal of the basic work that gave us mains electricity. Therefore all his electrical experiments were done with batteries, much the same as the type we use in cars today, except that they had to be made with new chemicals each time since there was no way of recharging them !

10 pairs of plates (see 1275 — it would seem to be pairs) to one trough would give a combined voltage of up to 20V, but probably not much current. From this it seems likely that the troughs (each battery) were connected in parallel; i.e. 20V but a bigger current available.

*finger basins* — We would use beakers today.

*small gas jars* — About the size of boiling tubes or large test tubes; we still use these for collecting small amounts of gas in experiments.

*same electric current* — Faraday means that it is the same current flowing through the two electrolysis cells, so that the effects can be compared directly. It is NOT the same current throughout the experiment as the battery runs down ( “at the end was much reduced in power”) This is a very neat piece of experimental design to ensure a fair test.

*Sul.acid* — sulphuric acid.

*S.G.* — Specific gravity — a comparison of the density of the acid with that of water (water would be 1000 on this scale). It is still the way we measure acid strength today, especially that of battery acid.

*platina* — platinum

*at pleasure* — when you are ready

*communicated with* — attached to

*Pos.pole // neg.pole* — positive terminal // negative terminal

## 607

*inch* — 2.54 cm

*cubical inch* — cubic inch = 16.4 $cm^3$

*the approach to equality great* — 1.9 is not the same as 2.2, so why does Faraday claim they are equal ? From this, he claims that the size of the electrode does not affect the electrolysis. However he then gives a reason for the difference.

## 1274 Nature of the electrodes

(the material the electrodes are made from)

*Expts.* experiments

*ascertain* find out

## 1275

*oil vitriol* (concentrated) sulphuric acid. Therefore 1:3 is the dilution of the sulphuric acid used.

*voltaic battery* See 'battery' above. Volta was an earlier experimenter and invented the first battery (the voltaic pile)

*Volta electrometer* There were no ammeters; again Faraday's later work in electromagnetism led directly to their invention. He used a 'standard' electrolysis cell; electrolysing water to produce oxygen and hydrogen. The amount of $O_2$ added to the amount of $H_2$ given off was used as a measure of the electric current. This version (N in the diagram) collects both gases in one tube - very dangerous !
See also 732 — 739.

*Action of acid on zinc both when out of contact and also in contact with the P.Pole of the battery* We would now call this 'local action' - the acid acting on impurities in the zinc

*c:i:* cubic inches. Note the use of the colon where we would now use a full stop.

Is the ratio of 1.04 : 1.53 exactly two thirds? Does any difference matter to Faraday's conclusion that the nature of the electrode makes no difference to the effect that the electric current has?

## 1846. Heat (temperature of the electrolyte)

*exalting* encouraging

*chemical affinity* reactions

*intensity of the current* the size of the current

*hot dilute S.A.* hot dilute sulphuric acid (but Faraday has not measured the 'heat')

*Mr.acid* Muriatic acid = hydrochloric acid

Note that Faraday seems to think that there is an effect here; "so that it is probable an effect was produced". However, he does not do anything about it; "The expt. is worth pursuing therefore, but I cannot spare the time for it here". Indeed there seems to be no record of him having tried it again!

*Faraday's papers were mostly published as soon as he had done the research. This meant that many people did not read them all and there were gaps in their knowledge of his work on electrochemistry at the time that he was working. Faraday himself recognised this and published this collected series of papers.*

Experimental Researches in Electricity
by Michael Faraday D.C.L. F.R.S
Volume 1 Second Edition 1849

Richard and John Edward Taylor

Printers and Publishers to the University of London
Red Lion Court Fleet Street

*Faraday tried out experiments on a very wide range of substances, using his 'volta-electrometers' to measure the electricity and his skills as a chemist to measure the amount of chemicals evolved and their chemical equivalents. Having very carefully considered water, and then sulphuric acid, he moved on to muriatic acid (hydrochloric acid) and to a whole series of other acids. From there he went on to try substances that did not contain water. These had to be melted to obtain a liquid; chlorides of tin, lead, and antimony, along with iodides of lead and potassium were electrolysed in this way. One of these experiments ( on chloride of tin) is reported.*

791. ... The negative electrode weighed at first 20 grains; after the experiment, it, with its button of alloy, weighed 23.2 grains. The tin evolved by the electric current at the *cathode* weighed therefore 3.2 grains. The quantity of oxygen and hydrogen collected in the volta-electrometer = 3.85 cubic inches. As 100 cubic inches of oxygen and hydrogen, in the proportions to form water, may be considered as weighing 12.92 grains, the 3.85 cubic inches would weigh 0.49742 of a grain; that being, therefore, the weight of water decomposed by the same electric current as was able to decompose such weight of protochloride of tin as could yield 3.2 grains of metal. Now 0.49742 : 3.2 : : 9 the equivalent of water is to 57.9, which should therefore be the equivalent of tin, if the experiment has been made without error, and if the electro-chemical decomposition *is in this case also definite*. In some chemical works 58 is given as the chemical equivalent of tin, in others 57.9. Both are so near to the result of the experiment, and the experiment itself is so subject to slight causes of variation (as from the absorption of gas in the volta-electrometer (...), that the numbers leave little doubt of the applicability of the *law of definitive action* in this and all similar cases of electro-decomposition.

792. It is not often I have obtained an accordance in numbers so near as that I have just quoted. Four experiments were made on the protochloride of tin, the quantities of gas evolved in the volta-electrometer being from 2.05 to 10.29 cubic inches. The average of the four experiments gave 58.53 as the electro-chemical equivalent for tin.
**Finally Faraday sums up:**

821. All these facts combine into, I think, an irresistible mass of evidence, proving the truth of the important proposition which I first laid down, namely , *that the chemical power of a current of electricity is in direct proportion to the absolute quantity of electricity which passes* (...). They prove too, that this is not merely true of one substance,as water, but generally with all electrolytic bodies; and, further, that the results obtained with any *one substance* do not merely agree amongst themselves, but also with those obtained from *other substances*, the whole combining together into *one series of definite electro-chemical actions* (...). I do not mean to say that no exceptions will appear: perhaps some may arise, especially amongst substances existing only by weak affinity; but I do not expect that any will seriously disturb the result announced.

## Commentary

**791. Measuring weight gain on electrodes (mass gain)**
This experiment is typical of many reported and shows the high accuracy that Faraday worked to. Remember there were no electronic balances, the fine work was done using pan balances just as the apothecaries did (pharmacists).

*grain* the smallest unit of weight used by apothecaries
1 grain = 0.0648 gram

Remember too that there were no electronic calculators. Although there were slide rules, these calculations were probably done by long division.

**792.** Faraday is checking accuracy by repeated experiments, using a range of readings.

accordance = in accord = agreement

**821. Summary, the laws of electrolysis**
Faraday believes that all his previous experiments have explored every possible variable and factor: ".. an irresistible mass of evidence, proving the truth ....".

Experimental Researches in Electricity
by Michael Faraday D.C.L. F.R.S
Volume 1 Second Edition 1849

Richard and John Edward Taylor
Printers and Publishers to the University of London
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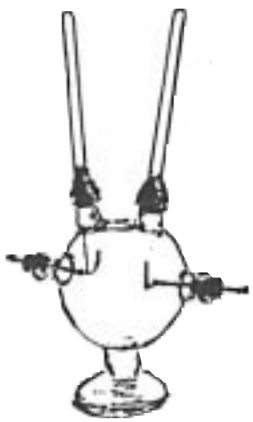
*On a new measure of Volta-electricity*

Faraday performed a series of experiments electrolysing water and from these developed an instrument that used the amount of gases evolved to measure electricity.

732. I consider the foregoing investigation as sufficient to prove the very extraordinary and important principle with respect to WATER, that when subjected to the influence of the electric current, a quantity of it is decomposed exactly proportionate to the quantity of electricity which has passed, not withstanding the thousand variations in the conditions and circumstances under which it may at the time be placed; and further, that when the interference of certain secondary effects (....) together with the solution or recombination of the gas and the evolution of air, are guarded against, the products of the decomposition may be collected with such accuracy, as to afford a very excellent and valuable measurer of the electricity concerned in their evolution.

736. .....When referred to as a comparative instrument .....it will not require particular precaution in the observation; but when used as an absolute measurer, it will be needful that the barometric pressure and the temperature be taken into account,



One version of Faraday's Volta-electrometer

.....

739. .....; I have therefore named it a VOLTA-ELECTROMETER.

## Commentary

There were no ammeters; again Faraday's later work in electromagnetism lead directly to their invention. He therefore used a 'standard' electrolysis cell; electrolysing water to produce oxygen and hydrogen. The amount of $O_2$ added to the amount of $H_2$ given off was used as a measure of the electric current.

**732.**

| | |
|---|---|
| *the foregoing investigation* | This was an exhaustive series of experiments that Faraday did to convince himself that no possible variable could make a difference to the effects that electricity had on water |
| *subjected to the influence of the electric current* | When current passed through it |
| *products of decomposition* | That is the gases, oxygen and hydrogen, in this case. |

The version shown collects the gases separately; and is very similar to Hoffman's voltameter. Adding the two gases together gives a measure of the electricity that has passed through. These days we would use an ammeter, which uses the swing of a needle to give a measure of the electric current. The most up-to-date ammeters measure current electronically.

This additional source material has been included and suggestions for its use with pupils are given in the Teachers' Notes. You can simply use it as teacher background information or suggest its possible use by colleagues in other subject areas for their own use or to encourage cross-curricular activities between departments.

**Contents**

# Faraday's correspondence with Benjamin Abbott, a friend of apprentice days

"The Correspondence of Michael Faraday"
Vol 1 1811- Dec 1831 Ed FAJL James

Pub - Institution of Electrical Engineers
1991 ISBN 0 863412483

## No 3 Faraday, still an apprentice, to Abbott

*Sunday Afternoon July 12th 1812*

Dear A.
..... But first let me wish you well , and then I will proceed on to the subject of this letter: Make my respects too if you please to Mr. & Mrs. Abbott, and also to your brother and sister.

.....

I have lately made a few simple galvanic experiments merely to illustrate to my self the first principles of science. I was going to Knights to obtain some Nickel & bethought me, that they had Malleable Zinc: I enquired and bought some. - have you seen any yet? The first portion I obtained was in the thinnest pieces possible; observe it in a flattened state, it was as they informed me, thin enough for the Electric Snake, or as I before called it, de Luc's Electric column. I obtained it for the purpose of forming discs, with which & copper to make a little battery. The first I completed contained the immense number of seven pair of Plates !!! and of the immense size of half-pennies each!!! I, Sir, my own self, cut out seven discs of the size of half-pennies each! I, Sir, covered them with seven half-pence and I interposed between seven or rather six pieces of paper, soaked in a solution of Muriate of Soda!!! - but laugh no longer Dear A——- rather wonder at the effects this trivial power produced, it was sufficient to produce the decomposition of the Sulphate of Magnesia; an effect which extremely surprised me, for I did not - could not have any idea, that the agent was component to the purpose. —— ——— a thought has struck me - I will tell you, I made the communication between the top & the bottom of the pile & the solution with the copper wire: do you conceive that it was the copper that decomposed the earthy sulphate?. that part I mean immersed in the solution; —— —-that the galvanic effect took place I am sure for both wires became covered in a short time with bubbles of some gas, & a continued stream of very minute bubbles, appearing like small particles, rose through the solution from the negative wire. My proof that the Sulphate was decomposed, was, that in about 2 hours the clear solution became turbid, Magnesia was suspended in it.

.....

And now dear Sir; to conclude in a manner requisite for this occasion, I humbly beg pardon for thus intruding on your time, your patience, & your good sense. I beseech you if you will condescend so far, to return me an answer on this occasion: & pray let the refusal of your correspondence be as gentle as possible ———-hoping dear A—- that the liberty I have taken will not injure me in your good opinion, I cannot conclude better than by wishing you all the happiness you can enjoy: .....

## No 40 Abbott to Faraday during the Grand Tour; sent via Paris, Faraday received it in Rome

*London Sunday 20th Nov 1814*

My Dear Michael!

The knowledge that the receipt of my letters affords you any pleasure would I can assure you be sufficient to induce me to write them even was the doing it a task instead of what it is - pleasure - Impressed with this Sentiment it is with a great degree of readiness & alacrity that I seize the present Opportunity of continuing a correspondence which affords us mutually so much Entertainment & which I trust distance will have no effect in impairing however much it may be impeding.

I have some fear at this time that the present text will find you already in Rome, which was not my intention it should but so many circumstances have lately intervened to prevent my perusing it sooner that I found it impossible & can therefore only say that should it arrive later than you have expected, its length must compensate for its delay... First then I must acknowledge the receipt of yours of the 6th Sept. from Geneva which reached me the
17th same...

... Your Mother, Brother & Sisters I believe are well; they were so a fortnight since I was there. Peggy you will be surprised to hear has with the assistance of my beloved Sister succeeded in prevailing on her mother to permit her to spend the day with us & if I can judge by her talk she would have no objection to repeat the visit...

*Nov.22 1814*

The Lectures at the Surrey Institution have commenced. There are 4 courses 1st on Chemistry by Mr Wheeler, 2nd on Extemporary Eloquence by Mr Rippingham 3d On the Passions & affections of the Mind & their Influence on Language & the Polite Arts by I.M.Good - 4th on Music by Dr Crotch - the first two are commenced but I have not yet heard Mr Rippingham he has delivered only one & from that I was unluckily detained by Business - my Sister however (who subscribes also) was there & I think she says he is an Orator I therefore expect some pleasure from hearing him. - Mr Wheeler has delivered 2 lectures - he is a young man who has never before appeared in Public & therefore labours under a great disadvantage from diffidence. This however will be soon overcome & I think he bids fairs to be a decent lecturer a first-rate one he cannot be from a slight defect in utterance...

... In a former Letter you promised me a full Sheet with a little of Vesuvius in it but I have not received it my last Epistle I supposed chased the Volcano out of your head. I hope by your next it will have returned - I have an extraordinary wish my Dear Mike to see one of these flaming furnaces & I think tho' you know I am not famous for Courage that my nerves would allow me to take a tolerable quiet look at it. - Pray have you seen many Cataracts? Mr K. my Companion in the Counting Ho has travelled in America & has seen the Falls of Niagara - he lent me his Manuscript Account & and also gave me some verbal particulars - from his relation it appears to me the seen can scarcely be less awful than a Volcano tho' of course differing much in its nature. The noise he compared to all the Cannon in the World keeping up an incessant roar all around you: as to what some persons have said of its being possible to go between the stream & the rock over which it falls he denies it altogether & says the place looks more like the Mouth of the Infernal Regions than anything else, & that any person attempting to go there would meet instant suffocation from the Spray & from the violent agitation of the air which he describes as so great 30 feet from the Stream as to oblige you every moment to turn around to recover the use of the Lungs.

I must here my Dear Michael think of drawing towards a conclusion of this tolerable long Letter - remember I shall be glad to see your writing if only three Lines - Therefore do not delay to answer it in any way as most convenient - should I not previously hear from you I intend to write again in about 3 or 4 Weeks. - Boyer Castle Magrath &c desire their kind

# Faraday's correspondence with Mary Somerville,

Faraday now an established researcher in his own right and Director of the Laboratory at the Royal Institution.

"The Correspondence of Michael Faraday"
Vol 2 1832- Dec 1840 Ed FAJL James

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## No 732 Faraday to Mary Somerville

*Royal Institution Mar. 1, 1834*

Dear Madam

I cannot refuse myself the pleasure any longer of thanking you for your kindness in sending me a copy of your work. I did intend to read it through first; but I cannot proceed so fast as I wish because of constant occupation.

I cannot resist saying too what pleasure I feel in your approbation of my late Experimental Researches. The approval of one judge is to me more stimulating than the applause of thousands that *cannot* understand the subject.

I am Dear Madam With Every Respect

*Your faithful Servant M. Faraday*

## No 821 Faraday to Mary Somerville

*Royal Institution 12 Oct 1835*

Dear Mrs. Somerville

I have been making some experiments with the papers but do not succeed in obtaining so good & regular a result as I wished and believed I might obtain.

In the first place the precipitates made upon the paper are not so sensible or regular as that first found & washed & applied in the normal way the excess of the muriate or nitrate used & the resulting salt formed interfering with action of light by retarding more or less the change and that in an irregular manner. Chloride produced on the paper is therefore nothing like so regular in its change as chloride previously precipitated & well washed.

In the next place I do not find that I can lay a more regular coat of the substance on the method I mentioned than by using the moist precipitated chloride & a camel hair pencil.

I suspect your chloride is a good deal discovered. I will therefore precipitate & wash some and send it to you in the moist state. Allow me to suggest that when you refer to and apply it to paper for your experiments you do so in a dark place or by candle light only & then you may keep it for a long time in good condition.

I send also Biots report for your inspection.

*Ever Your faithful Servant M.Faraday*

## No 825 Mary Somerville to Faraday Extract

*R.H. Chelsea 25th Oct*

How truly I am obliged to you my dear Sir for your kindness. The chloride of silver answers perfectly, and I took the advantage of the last sunshine to make experiments upon a variety of substances with success. There were some curious results, but time will be required & brighter weather to confirm them. I beg my best regards to Mrs Faraday

# Faraday's correspondence with Andre-Marie Ampere

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## No 654 Ampère to Faraday

*Paris le 13 Avril 1833*

My Very Dear Colleague,

I have intended to write to you for a long time, but I have been prevented from so doing both by affairs that needed immediate attention and by urgent work. Moreover, since I suffered a near-fatal chest infection three years ago, I have spent all my spare time exclusively on a work, the extent of which I could not have imagined when I undertook it at Hyeres in the south of France, where the doctors sent me as the only method of treatment which offered any hope. .....

I know, my dear colleague, ... , that you are .. a true friend of mine and I flatter myself that I merit this for the sentiments that I have for a long time felt for you and the keen desire that I shall always retain of finding an opportunity to do something to please you. It is this which allows me to speak with an open heart of something which caused me great sorrow, when I read the paper that you published on the experiments which have added so much to what was known of the phenomena produced by electricity in motion and which constitute one of the most beautiful discoveries of this century, .....

You will see that, in ... diverse passages: .. I talk of the production of an electric current by influence, as in an experiment which, ... is quite easy repeat, .... I carefully avoided speaking of the direction in which the induced current goes and how long it lasts, because I did not know this and did not look at this aspect.

...I truly cannot understand why you linked to the experiment in question the idea, supposedly put forward by me, that the current produced by induction would be *in the same direction* as the current which determines it, since, in what I wrote on this subject in 1822, I avoided, ....., to say anything about the direction or the length of the induced current .....
...I should be greatly obliged to you if you could tell, in the reply to this letter which I hope to receive because of your friendship, what made you attribute an opinion to me on this subject. ...

...I would be very grateful if in some new publication you were to find an opportunity of warning the people whom the love of science prompts to read attentively all that is published by one of the leading physicists in Europe, that what you say in your note in no way refers to the experiment done in 1822 (by Ampère)

It is certain that the experiments (Fresnel) did on the oxydisation of one of the ends of an iron wire shaped into a helix around a magnet whilst the other end covered itself in a calcareous deposit , were at first completely successful. .... but as Fresnel did not then know that distilled water could not conduct electric currents but that it could as soon as it contained a weak saline solution, since he paid no attention to the fact that the chalky deposit at one end of the wire was as clear a proof of the existence of an electric current as the oxydisation at the other end, he no longer tried to obtain the same effects with distilled water, which not allowing electric current to pass through, could not, in any case, give a result, and he soon abandoned all research on this subject.

Please accept, my dear colleague, my expressions of a most sincere friendship and the feelings which the great discoveries that science owes to you inspire in me as in all who are interested in its advances.

## No 654 Original French of Ampère's letter to Faraday

*Paris le 13 Avril 1833*

Mon très cher confrère.

Il y a bien longtemps que je désire écrire et que tantot une occupation uregente, tantot un travail présse m'en ont empeché, d'alleurs, depui l'affection de poitrine dont j'ai manqué mourir il ya trois ans, je me suis exclusivement occupé, pendant tout le tems dont je pouvais disposer, d'un travail dont je ne soupçonnais pas l'étendue quand je l'entrepris à hyères dans le midi de france, où les médecins m'enoyèrent comme seul moyen de guérison qui put laisser quelque espoir. ....

Je sais, mon très cher confrère, par cet excellent ami, que vous avez aussi pour moi une véritable amitié, et je me flatte de la mériter par les sentimens que je vous ai voués depuis longtems et par le vif désir que le conserverai toujours de trouver l'occasion de faire quelque chose qui put vous etre agréable. C'est ce qui m'autorise à vous parler à coeur ouvert d'une chose qui m'a fait quelque peine lorsque j'ai lu le mémoire que vous avex publié sur les expériences qui ont tant ajouté à ce qu'on savit sur les phénomènes produit par électricité en mouvement et qui constituent une des plus belles découvertes de ce siecle, .....

Vous remarquerez dans ces divers passage .. je parle de la production du courant électrique par influence, comme d'une expérience qui, ... est facile à répéter, ... j'ai évité avec soin de parler du sens dans lequel le courant par induction a lieu, et de dire quelle est sa durée, parceque je l'ignorais et n'avias pas cherché ce qu'il en était à cet égard

.. je n'ai pas compris de meme pouquoi vous aviez lié, a l'expérience dont nous parlons, l'idée, supposée émise par moi, que le courant produit par induction serai dans le meme sens que le courant qui détermime, puisique dans ce que j'ai écrit en 1822 sur ce sujet, j'ai évité, .... de rien dire sur le sens ni sur la durée du courant par induction,
.. je vous serais infiniment obligé de me dire, dans la réponse a cette lettre, que j'éspère de votre amitie, ce qui vous a fait m'attribuer une opinion à cet égard;....

..Je serais bien aise que dans quelques nouvelles publications, vous trouverassiez l'occasion de prévenir les personnes que l'amour des sciences porte à lire avec tant d'empressement tout ce que publie un des premiers physiciens del' Europe, que ce que vous dites dans cette note ne se rapporte en aucune manière a l'experience faite en 1822 (par Ampère).

Il est certain que les expériences qu'il (Fresnel) faisant sur l'oxidation d'une des extremités d'un fil de fer, roulé en hélice autour d'un aimant, tandis que l'autre extremité se couvrait d'un dépot de calcaire, avaient d'abord complètement reussi; mais, comme Fresnel ne savait pas alors que l'eau distillée n'était nullement conductrice du courant électrique et qu'elle le devenait dès qu'elle tenait en dissolution un peu de sel, comme il ne faisait pas attention que le depot calcaire, a une des extremités du fil, était une preuve tout aussi évidente de l'existence d'un courant électrique, que l'oxidation de l'autre extremité, il ne chercha plus à obtenir les memes effets avec l'eau distillée qui, faute de permettre le passage du courant électrique, ne pouvait, dans aucun cas, donner de résultat, et il abandonna bientot toute recherche sur ce sujet.
.....

Je vous en prie, Mon cher confrére, d'agréer l'expression d'une bien sincère amité, et des sentimens que m'inspirent, comme à tous ceux qui s'intéressent aux progrès des science, les grandes dècouvertes qu'elles vous doivent.

*Royal Institution May 4th 1833*

My dear Sir,

It gives me great pleasure at all times to have the honor of a letter or even a verbal message from you but that pleasure was on the occasion of your last letter mixed with pain that I should inadvertently have grieved you. I am extremely indebted to you for your kindness in putting me right and as I had a paper in the press I instantly stopped the printer's progress and applied to the President His Royal Highness the Duke of Sussex and obtained leave to attach a note to the paper amending my error. I have also urged the printer forward that I may procure a copy of the note which I now send to you and I hope you will find it everything that you wished for. I am exceedingly sorry for my mistake but when you have read the note I am sure you will not be surprised at it.

Occupation presses on me to such a degree that I barely have time now to write these few words and I think I may therefore assume that the note will answer the greater part of your letter.

I am delighted to find that you are experimenting on the subject and shall be quite anxious to read your paper on the action of heat. From what you state I should suppose the effects are altogether new but shall scrupulously refrain from making experiments or even thinking on the matter until I see your results.

I am still at work and shall send you papers as they come out. I have just sent in one - (my fourth series of experimental researches *) on a new law of Electric conduction to the Royal Society but it has not yet been read. I have another in hand but the experiments are incomplete.

Wishing you full recovery of health & spirits that you may still vigorously & successfully pursue what I know gives you such delight and is to you a source of so much honor.

I am My Very dear Sir *Yours Most Faithfully M.*

*Faraday*

(* These and subsequent papers are quoted from in this Pupil Research Brief)

My name is Jane Deval. I am sixteen years old and live with my family in Bird Street, just off Oxford Street, London, where my father has his shop. There are 7 in the family altogether but only three of us live at home now. My father's business is a saddlery, selling horse equipment to professional people like doctors and lawyers, sometimes to the gentry. He has to go out a lot to buy equipment for the shop and arrange for special orders to be made. Therefore it is mostly mother who runs the shop and I help her, although I am looking forward to being able to get married myself.

Both my oldest brother, Tobias, and my oldest sister Elizabeth are married with their own families. Tobias is a journeyman printer, working for a print firm in Fleet Street and lives over in Aldersgate. He comes over to see us sometimes with his wife Annie, and my nephew Thomas. Before she was married Elizabeth was in service with a well-to-do lawyer, eventually becoming under-parlour maid before she married George, one of his coachmen. The lawyer moved to Bristol and we never see Elizabeth now, although she does write regularly. The youngest of us children is Sophie who is 11 years old and a regular nuisance to me as I have to look after her. She goes to a dame school round the corner and is learning arithmetic now that she can read and write tolerably well.

My favourite brother, however, is James, now seventeen, who is apprenticed to Mr Forebeen an apothecary over down in Charles Street, near Berkeley Square. He only gets to come home on Sundays as a rule but Mr Forebeen is very good to him and encourages him to further his learning by going to lectures. We often go together and are both very interested in science. Father pays a subscription for both us to the Marylebone Literary and Scientific Institution, which is just off Portman Square. The lectures there cover many subjects and many are quite interesting. Sometimes we are able to afford tickets to go to Professor Faraday's lectures at the Royal Institution in Albemarle Street and he is such a good lecturer that I am fascinated by all he says.

When we do have tickets, I walk down to Charles Street and call at Mr Forebeen's shop for James. Neither father nor James is very happy with this arrangement but I feel that I am old enough now to walk through the streets on my own; other girls do. I will admit to being happier when with James as we walk round Berkeley Square to Albemarle Street. Wide though the pavements are in this area, there many beggars, street sellers and layabouts who can be very rude.

At least there are gas lamps here so you can see when it gets dark. When we reach Albemarle Street there is always a terrible crush of people all trying to get into the RI and carriages all over the place. Our seats are in the upper gallery as only the gentry take seats in the main hall. This month Professor Faraday is giving a series of eight lectures on metals and we saw his demonstration of one of the original electrical batteries. It looked quite simple and James and I made immediate plans to make one when he was next home. He promised to beg the chemicals from Mr Forebeen and I agreed to ask a plumber who lives along the road from us for some bits of the different metals.

This last Sunday James came home before noon and joined us in our first floor rooms. Our dining room is on the first floor over the shop itself but the kitchen is in the basement. Unlike some around here mother cooks for us all, with mine and Sophie's help. Recently father had a Rumford's range installed in the kitchen and this is so much better than the smoky old fire we had before. I think that, what with the shop and the lodgers in the garret, mother has too much to do and that we should get at least a maid-of-all-work. Father however says that the business does not yet make enough money to employ servants; what will he do when I get married and leave home?

Anyway, after dinner had finished, we cleared away the table in the dining room and James and I constructed our battery. When we had finished everybody gathered round to see what happened when we connected it up. We placed bits of copper wire at both ends and then to some very small wire strips and imagine their surprise when the strips burst into sparks. It was getting dark by then and so father lit a candle on the table and we played cards for a while and then had a light supper before it was time for James to go back to Charles Street.

During the week the shop is open from about 10.00 in the morning to around 7.00 in the evening. Other shops stay open later but our customers do not want to buy saddlery late in

My name is James Deval. I am seventeen years old and I am apprenticed to Mr Forebeen, an apothecary. As an apprentice, I live with my master at his house and shop in Charles Street, near Piccadilly, London. It is rather a grand house, with the shop and dispensary on the ground floor. Mr Forebeen and his family live on the first and second floors, while I and the upper servants live on the top floor. The kitchens and store rooms are in the basement and the lower servants sleep there also.

I am very lucky to have found an apprenticeship with Mr Forebeen. Not only is the apothecary's trade a good one but Mr Forebeen is an excellent master. The shop is also very prosperous, popular with the gentry from Berkeley Square and since joining him when I was fourteen I have learned to serve in the shop and am now learning how to make up common remedies and assist in the dispensary. Before I complete my apprenticeship I shall learn how to make up medicines prescribed by the doctors. My apprenticeship finishes when I am 21 years old and I will then have to find work for myself. I do however have hopes of staying on with Mr Forebeen as a journeyman and, as he has no sons, there is just the possibility that I may be able to take over the business.

There is another reason for this. Mr and Mrs Forebeen have been very unfortunate with their family. Altogether they have had four children, but two of them died when they were very young; one of diphtheria, the other nobody knows why. The remaining son would have been 22 this year but he was, by all accounts, rather strange and ran away to join the Indian Army when he was sixteen. He was killed in a riot in Calcutta two years later. That leaves Edith, the daughter of the household, who is fifteen and very pretty. She helps in the shop and, although Mr Forebeen never allows us to be alone together, we get along well and have an understanding between us.

The shop is open from 9.00 in the morning until 10.00 at night, from Monday to Saturday, and we are frequently very busy. Mr Forebeen pays a great deal of attention to my training, both practical and theoretical; indeed all the apprentices are kept busy. Mrs Forebeen organises the servants and the household very efficiently but looks kindly on me. Although there are four of us apprentices, I often feel that they look on me as a substitute son. Certainly both are concerned that my education should be rounded and not just in the apothecary business. Both my sister, Jane, and myself go to the lectures at the Marylebone Literary and Scientific Institution. I wish that they would allow me to take Edith but she has tutors at home and, if she goes out to lectures, it is with her parents. Sometimes, especially with the mathematics tutor, I am sent to take lessons as well.
On occasions I manage to get tickets for Professor Faraday's lectures at the Royal Institution in Albemarle Street. He is an excellent lecturer and science is a very exciting subject. I generally take my sister Jane and on the day of the lecture she walks down from our family home in Bird Street, off Oxford Street, and calls for me at the shop. This does mean that I do not have to ask for the time off to go and collect her. She is just sixteen and her insisting on walking alone through the streets at the back of Grosvenor Square worries me, and I know it worries father. There are just too many vagabonds around and the police are not always there when needed.

Last week, when we were in the gallery at the RI ( only the gentry sit downstairs), Professor Faraday demonstrated one of the original batteries. It was fascinating, especially to Jane, and she begged me to help her make one when I was next at home. I promised to ask Mr Forebeen for the chemicals while she said she would find the metals from a plumbers along the road from my family's saddlery shop in Bird Street. Science of all types fascinates me and maybe I will be able to train as doctor one day; I know a couple of medical students who started by training as an apothecary.

I only get Sundays off and then I generally go home to visit the family. Last Sunday was no exception and I took with me the chemicals needed for the battery. I know my mother tries hard to provide a good Sunday dinner but it is a bit awkward because she knows that at Charles Street the cook is extremely good. Anyway, after dinner had been cleared away, Jane and I constructed our battery and then showed to everybody. Imagine their surprise when we used it to make some thin wire strips burst into sparks. After this, father lit one candle and we played cards until it was time for me to walk back to Charles Street. I know father's business doesn't make a lot of money but I do think he might spare more than one candle, especially on a Sunday.

One of my jobs at Mr Forebeen's shop is to take purchases around to the gentry's house if they have not brought a servant out with them for the

# Character Story - Alice, Lady Mesbury 21st April 1845

My name is Alice, Lady Mesbury and my husband, Albert, Lord Mesbury, and I live at Mesbury Hall, near Stoke Fathlong in the county of Bedfordshire. I first met Albert at a grand ball given at Woburn by the Duke and Duchess of Bedford in 1831.We were married in 1834 when I was just 19. Mesbury Hall has been in my husband's family for over four generations and each of the previous generations has extended it so that there is now a reasonable size ball room, excellent stables and some 15 bedrooms. I have my drawing room and Albert has his library, the dining room is a good size (seating around 20 when occasion demands), and the children have their own rooms, including the school room. The inside staff numbers about 40, including the children's governess, with as many, or more, working on the estate.

Rather than extend the Hall ourselves, I have persuaded Albert to modernise our town house in Bruton Street, just off Berkeley Square. I have always been interested in the use of science, and Albert is always keen to make the most of new inventions so, soon after we were married, we had Rumford grates fitted in all rooms and now we have also had water piped in at sufficient pressure as to be able to pipe water to all floors of the house. This means that we have water closets on all floors. As Bruton Street has gas street lights we also had gas piped into the house so that there are gas lamps in the main rooms. These give excellent light and are very much the envy of many of our friends.

When we travel to London in the season, we generally travel in one of our own carriages so as to have its use in town. My maid and Albert's valet come with us but nowadays we send most of the servants by railway from the station at Bletchley to Kings Cross.

At Mesbury Hall I look after the day-to-day management, supervising the housekeeper, cook and butler, while Albert directs the estate in general and takes a particular interest in the horses. On days when we are not entertaining I like to spend time in some rooms in the stable block that I have had converted to enable me to do the science experiments that I am exploring with the help of publications from the Royal Society that are posted to me from London. There are some fascinating areas in electricity and chemicals and when I am in London I learn about some of these.

We do far more entertaining in London of course and consequently I get far less time for my scientific enquiry.
London is also the place to go shopping and I do enjoy looking at all the latest fashions before buying. Bond Street is a favourite shopping street and also Burlington Arcade which is not far from it. When shopping on my own I take my maid with me and generally a footman to carry the packages and ward off the beggars when necessary.
There are other streets of course and for medicines and so on I go to an apothecary's in Charles Street, on the other side of Berkeley Square. The apprentice there (one James Deval) is a handsome young fellow, very knowledgeable and keen to serve. I have got into the habit of asking for him to take my purchases over to Bruton Street and arrange with the butler to give the lad a tip when he does so.

Another pleasing aspect of London is that I can go to the lectures at the Royal Institution and hear of the latest in science from eminent men. There is also the opportunity to discuss matters with other members of the audience. Both Albert and I are members and I take every opportunity I can to attend lectures of general interest and especially any on electricity and chemistry. Those given by Professor Faraday are always first-rate and I can sometimes seize an opportunity to speak about my ideas with the professor himself.

My other concern in life is obviously the children. In age order, there is Emily, Joseph, Harry and Evangeline; we did have another baby, Edward, but he died of diphtheria soon after he was born. I am expecting another child in about six months time. The children have a governess who looks after their schooling but Albert has insisted that the boys be sent away to school when they reach the age of 10. Although this is later than some families send their boys to school, I still think that this is unnecessarily early and I worry about Joseph who is now at Shrewsbury, like his father was before him. One hears such tales of brutal behaviour at public schools. The governess is an excellent woman, but lacking in a scientific and mathematical background so I tutor the children in these areas. Although the governess has charge in the

# Character Story - Albert, Lord Mesbury 21st April 1845

My name is Albert, Lord Mesbury and my estates are near Stoke Fathlong in the county of Bedfordshire. Mesbury Hall and its estates have been in my family for four generations. My great-grandfather built the original hall in 1760 and each generation in turn has tried to improve both the hall and the lands of the estate. Apart from the land immediately around the hall, most of the estate consists of 6 farms run by my tenant farmers and overseen by my estate manager, George Feather, and there are also two hamlets, a lake and about two hundred acres of woodland. The title came originally from King George III, as a reward for support in some political problems. Much of the original money came from trading in slaves but it was my father that took the family out of that business.

The hall itself is quite spacious these days, 15 or so bedrooms, a library for myself and a drawing room for my wife Alice, Lady Mesbury, a dining room which will take 20 at a push, and a ball room that is adequate for our purposes. The stables are in excellent condition. Built by my father, and with some improvements I have made myself. They can house about 15 horses, including my favourite stallion, 'Dancer', a product of some very good breeding lines on the estate.

We have four children, two boys and two girls. The girls are educated at home of course with first a nanny and then a governess; with Alice supervising overall. I know that she would like the boys to be educated the same way but I cannot allow this as the boys must go away to school. All men of our class need to have a proper education and this means one of the great schools, Shrewsbury in our case. I have been lenient and allowed the eldest, Joseph to stay at home until he was 10, two years ago. Harry will follow him next month and they will both have to learn to like it; it never did me any harm.

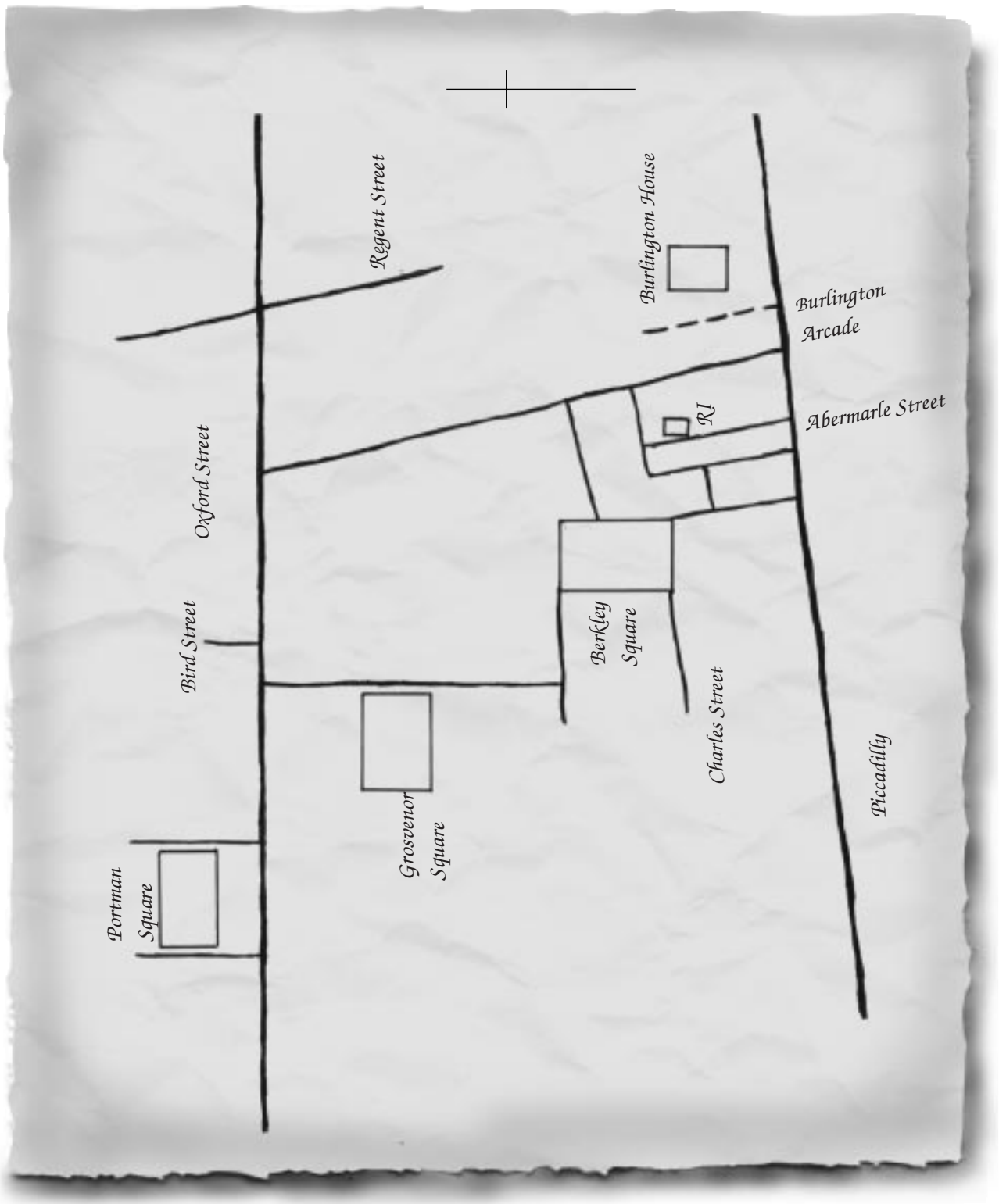
I met my wife when I was a cadet in the Royal Engineers. We married two years later and my father died soon after of consumption. He was 45 years old at the time, my mother having died in child birth some fifteen years previously. As eldest, I inherited the estate and of my two brothers, one is now a major in the Royal Artillery and the other a cleric with his own parish over in Cambridgeshire. It was as a cadet in the Royal Engineers that I first met Professor Faraday when, as plain Mr Faraday, he lectured on Chemistry to us cadets over at the Woolwich Arsenal.

Obviously we have to spend time down in London in order to see and be seen in the right company and for me to keep up with my business interests in Town. We have a small house (just four main rooms, six bedrooms and the necessary servants quarters) in Bruton Street, off Berkeley Square. I am keen to make use of useful inventions and Alice is very interested in all things scientific so we have spent a great deal of money updating the house, both when we were first married and since. Open fires are a nightmare in a small house so I had Rumford Grates put in. In London there is now pressured water available from the water companies so we have water piped to all floors and this saves on servants as there is no longer a need for them to carry water about the house. Although some consider the gas supply to be quite dangerous, I had gas piped in and the new lamps in the drawing and dining rooms give far better light than candles. After all, candles must be more dangerous than the gas, which is controllable.

Up at Mesbury Hall, Alice indulges her taste for science experiments with a laboratory we had installed in the stable block. I must say that some of the work she does there is very interesting and she has been able to show me some fascinating work on water pressure. Using this and my journals from the Institute of Civil Engineers in London I have been able to improve the water supply to our farms and irrigate some very dry land on the South of the estate. It is important to keep improving things and to provide as much employment as one can for there are many families starving because the menfolk are unemployed.

Among my clubs in London, I am a member of the Athenaeum and also of the Royal Institution, which is in Albemarle Street, towards Piccadilly. In the library there one gets to hear of some very useful ideas for improving the farming land and also about new ventures. I always try to invest in some of these ventures, both to make money myself and to encourage the inventors themselves. There is some talk of setting up the Electric Telegraph Company next year and I may well make some investment in that. Alice is also a member of the RI, as it does excellent scientific work especially under Professor Faraday. He is a still brilliant lecturer and I am always happy to accompany Alice when she wishes to go and hear him speak.

# Sketch map of part of the West End of London



Faraday's papers were mostly published as soon as he had done the research. This meant that many people did not read them all and their were gaps in their knowledge of his work on electrochemistry at the time that he was working. Faraday himself recognised this and published this collected series of papers.

Experimental Researches in Electricity
by Michael Faraday D.C.L. F.R.S
Volume 1 Second Edition 1849

Richard and John Edward Taylor
Printers and Publishers to the University of London
Red Lion Court, Fleet Street

## The Language of Electrolysis

Series VII Jan 1834

661. The theory that I believe to be a true expression of the facts of electro-chemical decomposition, and which I therefore detailed in a former series of these Researches, is so much at variance with those previously advanced, that I find the greatest difficulty in stating results, as I think, correctly. Of this kind is *pole*, with its prefixes of positive and negative, and the attached ideas of attraction and repulsion. .....

662. To avoid, therefore, confusion and circumlocution, and for the sake of greater precision of expression than I can otherwise obtain, I have deliberately considered the subject with two friends, and with their assistance and concurrence in framing them, I purpose henceforward using certain terms, which I will now define. ..... In place of the term pole, I propose using that of *Electrode*, and I mean thereby that substance, or rather surface, whether of air, water, metal, or any other body, which bounds the extent of the decomposing matter in the direction of the electric current.

663. ..... Upon this notion we purpose calling that towards the east the *anode* , and that towards the west the *cathode*. ..... The anode is therefore that surface at which the electric current, according to our present expression, enters; it is the *negative* extremity of the decomposing body; it is where oxygen, chlorine, acids, &c., are evolved; and is against or opposite the positive electrode. The *cathode* is that surface at which the current leaves the decomposing body, and is its *positive* extremity; the combustible bodies, metals, alkalies, and bases, are evolved there, and it is in contact with the negative electrode.

664. .....Many bodies are decomposed directly by the electric current, their elements being set free; these I propose to call *electrolytes.* .... Then for *electro-chemically decomposed*, I shall often use the term *electrolyzed.* ... The term electrolytical will be understood at once; muriatic acid is electrolytical, boracid is not.

665. ... Substances are frequently spoken of as being *electro-negative*, or *electro-positive*, according as they go under the supposed influence of a direct attraction to the positive or negative pole. But these terms are much too significant for the use to which I should have to put them; for though the meanings are perhaps right, they are only hypothetical, and may be wrong; and then, through a very imperceptible, but still very dangerous because continual, influence, they do great injury to science by contracting and limiting habitual views of those engaged in pursuing it. I propose to distinguish such bodies by calling those *anions* which go to the *anode* of the decomposing body; and those passing to the *cathode, cations;* and when I have occasion to speak of these together, I shall call them *ions.* Thus the chloride of lead is an *electrolyte*, and when *electrolyzed* evolves the two *ions*, chlorine and lead, the former being an *anion*, and the latter a *cation*.

666. These terms being once well-defined, will, I hope, in their use enable me to avoid much perphrasis and ambiguity of expression. I do not mean to press them into service more frequently than will be required, for I am fully aware that names are one thing and science another.

667. It will be well understood that I am giving no opinion respecting the nature of the electric current now, beyond what I have done on former occasions .....; and that I speak of the current as proceeding from the parts which are positive to those which are negative..., it is merely in accordance with the conventional, though in some degree tacit, agreement entered into by scientific men, ....

## Commentary

661. Faraday is trying to get away from the language used in what we today call electrostatics.

662. The ideas and names of electricity were still being debated in Faraday's time. Not everyone was convinced that all electricity was the same thing. Indeed Faraday actually did experiments to illustrate that they are.

*I have deliberately considered the subject with two friends*

The two friends were well known, highly regarded people. One interpretation of Faraday not including their names was that he wanted to protect them if people thought the ideas silly. He had had no education in Latin or Greek and so turned to his friends for advice on making up the words he needed. (Faraday did however know French and