

CELL CHARGE AND DISCHARGE MEMO

Purpose

- Learners are guided through the basic aspects of an experimental investigation.
- Learners plan an additional investigation of their own.

Suggested teaching approach

Estimated time	Description	Resources
Class time: 1 lesson	<ul style="list-style-type: none"> • Explain the necessary theory about batteries and about the scientific method. • Show learners the movie or perform the investigation yourself. • Discuss the investigation. Refer to: variables, focus question, hypothesis, results, conclusion, discussion. 	Cell charge and discharge movie Worksheet (p.39)
Homework time: ½ hour	<ul style="list-style-type: none"> • Learners answer questions 1-16 in writing. 	Worksheet (p.39)
Class time: ½ lesson	<ul style="list-style-type: none"> • Go through the answers to questions 1-16 with the learners. • Conduct a class discussion on further investigation possibilities (questions 17-22). Note that a number of possibilities could be correct: not only the one suggested here. 	Memo Worksheet
Homework time: ½ hour	<ul style="list-style-type: none"> • Learners answer questions 17-22 in writing. 	Worksheet

Check the learners' work.

Additional time should be allowed if you want to perform the experiment in class.

Practical tips

- Make sure you use a low-voltage (2,2V) bulb. An LED will also work, but takes a long time to discharge the cell.
- Allow the cell to charge for a while before you begin collecting data. PbO_2 forms in this time.
- Short-circuit the cell by placing a wire across the electrodes, before each charge.

Suggested answers to questions

Variables

- 1 **Independent variable:** **A cell's charge time.**
(Cause. What the investigator made different between the treatments.)
- 2 **Indicator of the dependent variable:** **Time bulb shines**
(Measurement of effect. What the investigator measures to show the investigation outcome.)
- 3 **Dependent variable:** **A cell's discharge time.**
(Effect. Different between the treatments because they had been treated differently from the start.)
- 4 **Controlled variables** (list at least three). (Must be kept the same between treatments for a fair test.)
concentration of electrolyte (sulfuric acid solution); PD during changing; temperature; distance between electrodes; surface area of electrodes; types of substances used for electrodes and electrolyte

Focus question

- 5 How does **a cell's charge time** [independent variable] affect **its discharge time?** [dependent variable]

Hypothesis

- 6 Guess what the answer to the focus question might be.

The learner should give his/her guess.

- 7 Justify your hypothesis, referring to the background theory.

The learner should justify his/her hypothesis, referring to theory.

Table

8 Circle the correct options to complete general rules for drawing a table.

Optional	Dependent variable / Independent variable / Indicator of dependent variable	Dependent variable / Independent variable / Indicator of dependent variable
A	Values showing how investigator treated	Values showing how investigator treated treat-
B	treatments differently / Measurements	ments differently / Measurements
C	made to show investigation outcome	made to show investigation outcome
D		

9 Units (e.g. min or s) should be given only in the [heading / body] of the table.

10 The abbreviation for the unit seconds is [sec / s].

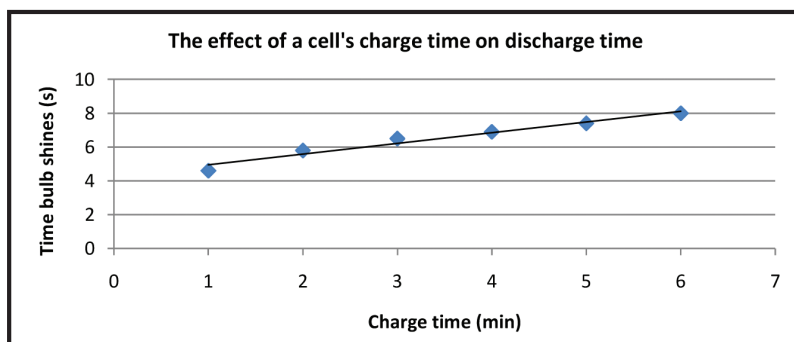
11 Calculate the averages for each treatment:

The effect of a cell's charge time on its discharge time

	Charge time (min)	Time bulb shines (s)	
		Raw data (3 repetitions)	Average
A	1	4,5 ; 4,7 ; 4,6	4,6
B	2	6,0 ; 5,9 ; 5,5	5,8
C	3	6,4 ; 6,4 ; 6,7	6,5
D	4	6,9 ; 6,9 ; 6,9	6,9
E	5	7,3 ; 7,9 ; 7,0	7,4
F	6	8,1 ; 8,4 ; 7,5	8,0

Graph

12 Represent the findings graphically.



Check. Has the learner:

- given a suitable graph heading?
- plotted the independent variable on the x (—) axis?
- plotted the indicator of the dependent variable on the y (|) axis?
- labelled each axis and given units where appropriate?
- accurately plotted data points with small circled dots?
- drawn a smooth trend line?

Tick if done:

Conclusion

13 Answer the focus question in your own words.

The longer you charge the battery, the longer the light shines (the longer the battery can discharge). A battery's discharge time is directly proportional to its charge time.

14 Complete for a shorter way of writing the conclusion.

Increasing a cell's charge time [increases / decreases / doesn't affect] its discharge time.

Discussion

15 Was your hypothesis shown to be correct or incorrect? **Depends on learner's hypothesis.**

16 Suggest a reason for your findings, referring to the background theory.

The charging process restores chemicals to the state they need to be in to restart the discharge process. The longer the charging time the more chemicals can be restored to the state needed for the discharge process, and therefore the longer the subsequent discharge time can be. Of course, this is only up to a point. If the battery is already fully charged — with all its chemicals restored to the state ready for discharge — then charging it longer doesn't help: it won't discharge for longer because it has reached its capacity already.

We can also explain this in terms of energy. Charging converts electrical to chemical energy. This chemical energy can then be converted back into electrical energy during discharging. The longer the period of charging, the more electrical energy is stored as chemical energy, and therefore the more chemical energy is present to be able to be converted back into electrical energy during discharging. Again, this is only up to a limit.

Further investigation: Possible answer

Design another investigation of your own, using the guidance given below.

It must have a different focus question to the previous investigation.

Note that there are other answers which could be correct too.

Variables

Complete / Give the:

- 17 **Independent** variable. **A cell's electrolyte concentration.**
Dependent variable. **A cell's discharge time.**
- 18 **Controlled** variables. (Must be kept the same between treatments for a fair test.)
 Compared to the previous investigation, give one variable which:
 a must be constant between treatments here, but not previously **the cell's charge time.**
 b must not be constant between treatments here, but must be previously
the electrolyte concentration (or whatever learner chose as their dependent variable here).

Focus question

Complete:

- 19 How does **a cell's electrolyte concentration** affect **its discharge time?**
 [independent variable] [dependent variable]

Method

20 Treatments differ in: **electrolyte concentration**

Note: these values are only suggestions: any reasonable values are acceptable:

A: 0,1 M H₂SO₄(aq)

C: 1 M H₂SO₄(aq)

B: 0,5 M H₂SO₄(aq)

D: 1,5 M H₂SO₄(aq)

21 Explain what you would do in this investigation.

Mix different concentrations of sulfuric acid solutions.

Charge each cell for a certain amount of time (e.g. 1 minute).

Record the time for discharge for each cell.

Table

22 Fill in headings and values showing how you will treat the treatments differently.

Include units in headings where appropriate.

Leave empty spaces where you could fill data in after taking measurements.

The effect of a cell's electrolyte concentration on its discharge time

	Electrolyte concentration (M)	Time bulb shines (s)
A	0,1	
B	0,5	
C	1	
D	1,5	