

Independent Variable

The independent variable is the one condition that you change in an experiment.

Example: In an experiment measuring the effect of temperature on the rate of a reaction, the independent variable is temperature. In other words the independent variable is the condition that is changed

Dependent Variable

The dependent variable is the variable that you measure or observe and its behaviour is dependent on how the independent variable is changed..

Example: In the experiment measuring the effect of temperature on the rate of a reaction, the dependent variable is the rate.

Controlled Variable

A controlled variable is a variable that does not change during an experiment.

Example: In the experiment measuring the effect of temperature on the rate of a reaction, controlled variables could include the size and shape of the container used in the experiment.

Systematic errors are errors that occur consistently and to the same extent every time the experiment is conducted. These errors include errors with the procedure, consistently reading the instruments wrongly, as well as the built in error of instruments such as electronic scales. Conditions such as room temperature can also introduce systematic errors.

Random errors cause random variations in the results or observations obtained. Let's say we use a burette to measure the volume of solution delivered. The burette allows us to read the volume to $\pm 0.05\text{mL}$. We may obtain a set of readings in mL such as: 12.73, 12.67, 12.85.

The variation in these figures is probably due to the fact that the experimenter may have occasionally read the scale on the burette at an angle other than at the perpendicular to the scale. This will introduce parallax error into the results and cause random variations in the measurements.

Experimental technique.

Revision 1

Electroplating an iron key with copper metal

Aim

To investigate whether Faraday's laws apply to the electroplating of a brass key with nickel

Procedure

The apparatus was set up as in the diagram above. The electrolytic cell was filled with the electrolyte solution provided, 0.10 M CuSO_4 .

Step 1 – The iron key was sanded, weighed and placed in the solution, as shown above.

Step 2 – A current was applied for exactly 20.0 minutes. Both the current and voltage were measured once, when the power was turned on.

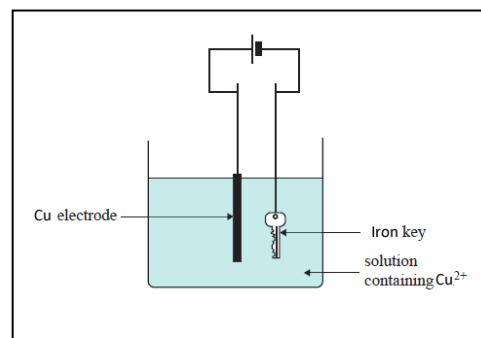
Step 3 – The key was removed from the solution, washed with acetone, allowed to dry and weighed to constant mass.

Steps 1–3 were repeated for two more keys .

Results

Three trials of the experiment were conducted as shown in the table below.

Trial	Initial mass of key (g)	Final mass of key (g)	Mass of copper deposit (g)	Current (A)	Voltage (V)
1	2.105	2.271	0.166	0.210	2.4
2	2.952	3.104	0.152	0.192	2.2
3	3.115	3.305	0.190	0.221	1.9



1) The student wrote in their report

Conclusion- Faraday's laws apply to the electroplating of an iron key with copper. Do you agree with this conclusion? Provide evidence to support your decision based on trial 1 and 2.

2) Consider trial 3 what mass of copper should have deposited on the key?

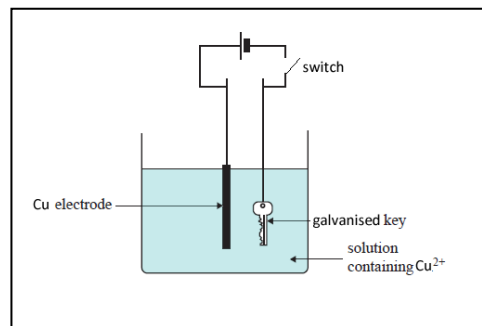
3) Evaluate the student's experimental design:

- identify and explain **one** strength of the experimental design

- suggest **two** improvements or modifications that you would make to the experimental design and justify your suggestions

4) A student offered the following suggestion to an improvement or modification. "A fresh electrolyte solution should be used for every trial as the concentration of Cu^{2+} ions changes. Discuss how valid this modification is.

5) Consider the electrolytic setup shown on the right. A galvanised iron key is to be plated with copper. The key is connected to the open circuit (switch is off) and immersed in the electrolyte. Five minutes later the switch is turned on and the current and voltage measured. Galvanised steel has a layer of zinc placed on its surface. How will this influence the ratio of mass / current obtained in the above investigation with a pure iron key. Explain your answer with reference to the electrochemical series.



6) The experimental setup pictured on the right is used to verify Faraday's second Law. Two electrolytic cells are connected in series. A current is passed through each cell for 20 minutes. The mass of metal deposited on each cathode is then measured.

Faradays second law states, 'The amount of electricity, in coulombs, required to produce 1 mole of a substance is a simple whole number multiple of 96500. "

a) What are the dependent and independent variables?

b) Which of the following variables should be kept constant between the two electrolytic cells?

- i. The concentration of the copper and silver solutions
- ii. The shape and size of the electrodes.
- iii. The volume of the each solution
- iv. The depth to which each electrode is submerged in the solution.

c) Mention one other variable that is kept constant.

of Fe in the rock would be lower than its true value.

d) Wash the rock with concentrated HCl solution, if this is not done the percentage of Fe in the rock would be lower than its true value.

- 2) Which one of the following should be done before step 2?
- Add 80 mL of concentrated HCl to dissolve all the Fe_2O_3 present.
 - Accurately weigh the beaker and its contents
 - Allow the beaker to stand for several minutes to allow the precipitate to settle to the bottom of the beaker.
 - The contents of the 500 mL beaker should be filtered to remove any undissolved rock particles.
- 3) Which of the following is a critical error of the experimental procedure?
- The mass of the crucible must be known before step 3
 - The mass of the dry filter paper should be known before step 3
 - There is no need to heat the crucible and its contents to constant mass.
 - The volume of NaOH added at step 2 should be accurately known.
- 4) Which of the following options **best** explains the accuracy of the final result and why?
- It is not accurate as it is given to 2 significant figures and it should be given to 3 significant figures.
 - It is very accurate as care was taken to remove all the Fe present and weigh it accurately using an electronic balance.
 - It is highly inaccurate as the filter paper has not been accounted for in the final mass of Fe.
 - It is highly inaccurate as the mass of the crucible has not been taken into account.
- 5) On the right is the section on errors that was given by another group of students. Which of the following comments is true?
- Error 1) is a random error.
 - Error 2) is a human error and should not be included in the report.
 - Both 1) and 2) are random errors and should not be included in the report.
 - Both 1) and 2) are systematic errors and as such it is right to include them in the report.

Errors

1) the label on the balance indicates an error of +/- 0.005g

2) We accidentally spilled some of the precipitate when transferring it to the balance for weighing.

The following material relates to questions 6 -7

Results		
	Trial 1	Trial 2
Volume H ₂ O ₂	100 mL	200 mL
Concentration H ₂ O ₂	1.5 M	1.5 M
Catalyst	0.5 g KI	50 mL 0.1 M Fe(NO ₃) ₃
Temperature change °C	2.5	2.3

A student conducted an investigation to understand the impact of using different catalysts on the molar enthalpy of decomposition of hydrogen peroxide according to the equation $\text{H}_2\text{O}_2(\text{l}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$.

Two trials were conducted and the results are presented in the table above.

- 6) What is a reasonable conclusion for this investigation?
- a) A greater molar enthalpy is achieved when KI is used as a catalyst than with Fe(NO₃)₃
 - b) Fe(NO₃)₃ is not as effective as KI as catalyst for this reaction
 - c) No conclusion can be reached.
 - d) Fe(NO₃)₃ is better at catalysing this reaction than KI
- 7) Another student, Jack, argued that this is not a fair test. Which comment below is true?
- a) This is a fair test as both trials use the same concentration of H₂O₂
 - b) This is not a fair test as both trials need to have different concentrations of H₂O₂
 - c) This is not a fair test as both trials need to have the same amount of H₂O₂ present and the catalysts need to be in the same state and same amount while the volume of water also needs to be consistent.
 - d) This is a fair test as both trials were conducted at the same room temperature and similar glassware was used and the temperature measured over the same time frame..