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Education Services

Pre-IB Chemical Research Skills Programme

Chemical Research Skills

A Skills-Building Programme for Independent Chemical Investigation

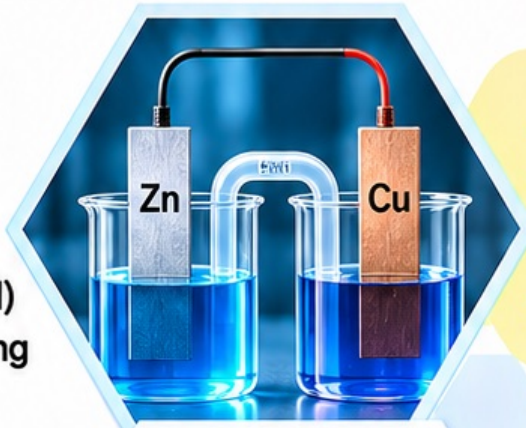


Module 10 | Worksheets

Student Practice & Application

Module Focus

- Principles of electrochemistry
- Constructing and using a voltaic cell (galvanic cell)
- Measuring and interpreting cell potential (E_{cell})
- Factors affecting cell potential
- Applications of electrolysis (e.g. extraction, electroplating)
- Relating experimental findings to redox processes and electron transfer



Key Concepts

- Redox and electron transfer
- Cell notation
- Standard electrode potential ($E°$)
- Electrolysis and its applications

Cell Notation

$Zn(s) \mid Zn^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$

Overall Reaction

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$



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Module 10 — Student Worksheets

From Research Question to Experimental Method

How Do We Design a Complete, Reproducible and Scientifically Defensible Chemical Investigation?

Pre-IB Chemical Research Skills Programme

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Related 1-Minute Chemical Research Skills episodes:

- **Episode 24:** From Research Question to Experimental Method
- **Episode 25:** What Makes an Experimental Method Scientifically Defensible?

Prerequisite: Module 9 — Designing the Measurement Strategy

Programme position: Final Module — Integration of Chemical Research Skills

Student's name: _____

Class: _____

Date: _____

Module Learning Objectives

By completing these worksheets, students should be able to:

1. Translate a research question into a complete experimental plan.
2. Explain the chemical principles supporting an investigation.
3. Identify independent, dependent and controlled variables.
4. Develop operational definitions for measured quantities.
5. Select suitable apparatus, reagents and analytical techniques.
6. Calculate reagent quantities and determine limiting reagents.
7. Prepare appropriate solution concentrations.
8. Write clear and reproducible experimental procedures.
9. Plan calibration, blanks and control experiments.
10. Distinguish repeated readings from independent experiments.
11. Design appropriate raw-data and processed-data tables.
12. Plan calculations and graphical analysis.
13. Identify experimental uncertainty and limitations.
14. Develop appropriate laboratory risk-control measures.
15. Evaluate and improve incomplete experimental methods.
16. Justify experimental decisions using chemical reasoning.
17. Construct a complete chemical research proposal.

The worksheets progress through seven stages:

Define → Justify → Calculate → Design → Measure → Evaluate → Integrate

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SECTION A — FROM RESEARCH QUESTION TO EXPERIMENTAL PLAN

Worksheet 1 — Research Question vs Measurement Strategy vs Experimental Method

Consider the following three statements.

Statement A

How does hydrochloric acid concentration affect the initial rate of hydrogen production from magnesium?

Statement B

Measure hydrogen gas volume against time using a gas syringe and determine the initial gradient of the gas-volume–time graph.

Statement C

Transfer 25.0 cm^3 of hydrochloric acid into a reaction vessel, introduce a prepared magnesium sample and record hydrogen gas volume at specified time intervals.

Question 1

Classify each statement.

Statement Research question / Measurement strategy / Experimental method

A _____

B _____

C _____

Question 2

Explain the purpose of a research question.

_____

_____

Question 3

Explain the purpose of a measurement strategy.

_____

_____

Question 4

Explain the purpose of an experimental method.

_____

_____

Complete

Research Question} →_____ →Experimental Method

_____

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Worksheet 2 — What Is Missing from This Method?

A student writes:

"Prepare different concentrations of hydrochloric acid. Add magnesium. Measure the reaction and repeat."

Question 1

Identify **eight important details** missing from this proposed method.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Question 2

Why is the statement "measure the reaction" scientifically inadequate?

_____

_____

Question 3

Why is the instruction "repeat" incomplete?

_____

_____

Question 4

Rewrite the proposed method as a more scientifically useful summary.

_____

_____

_____

_____

_____

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Worksheet 3 — Identifying Variables

Research question:

How does temperature affect the initial rate of reaction between magnesium and hydrochloric acid?

Question 1

Identify the independent variable.

Question 2

Identify the dependent variable.

Question 3

Identify five controlled variables.

1.
2.
3.
4.
5.

Question 4

Explain why controlling variables is necessary.

Question 5

Does identifying a controlled variable automatically mean it has been controlled?

☐ Yes

☐ No

Explain.

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Worksheet 4 — From Variables to Experimental Controls

Complete the following table.

Controlled variable	Why it matters How it will be controlled
Temperature	
Magnesium mass	
Magnesium surface area	
Total solution volume	
Reaction apparatus	

Question 1

Why is controlling magnesium mass alone insufficient to guarantee constant surface area?

Question 2

A student uses magnesium samples with the same mass but different shapes.
Explain how this could affect the results.

Complete

[Identifying a controlled variable]≠_____ it

SECTION B — SCIENTIFIC RATIONALE AND HYPOTHESES

Worksheet 5 — Why Should the Method Work?

Consider:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Question 1

Identify the gas produced.

Question 2

Explain why measuring gas volume against time can provide information about reaction rate.

Question 3

Suggest a suitable instrument for measuring gas volume.

Question 4

What does the initial gradient of a gas-volume–time graph represent?

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