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Education Services

Pre-IB Chemical Research Skills Programme

Chemical Research Skills

A Skills-Building Programme for Independent Chemical Investigation



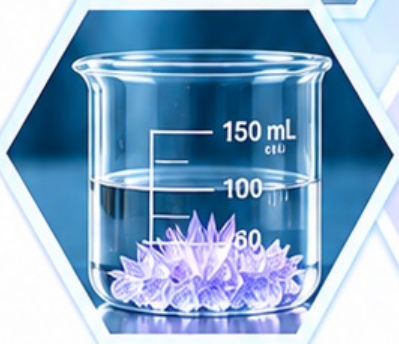
Module 9 | Worksheets

Student Practice & Application

Module Focus

- Principles of recrystallisation
- Choosing a suitable solvent
- Performing recrystallisation and obtaining pure crystals
- Assessing purity (e.g. melting point)
- Calculating percentage yield and discussing losses



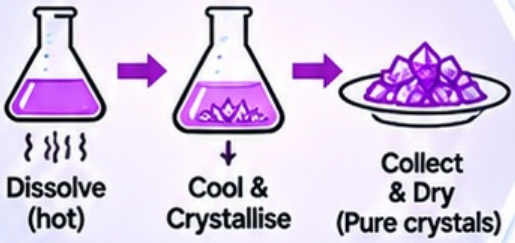


Key Concept

Recrystallisation

Purify a solid by dissolving it in a hot solvent and allowing pure crystals to form on cooling.

Overall Process



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Founder, LearningSparks Education Services
Creator of the CHIAM Framework™

Module 9 — Student Worksheets

Designing the Measurement Strategy

How Do We Plan Measurements That Can Actually Answer Our Research Question?

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Student: _____

Date: _____

Related 1-Minute Chemical Research Skills episodes:

- **Episode 22:** Choosing the Right Measurement Range
- **Episode 23:** Choosing the Right Analytical Technique

Prerequisite: Module 8 — Reliability, Accuracy & Data Quality

Next module: Module 10 — From Research Question to Experimental Method

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Module Learning Objectives

By completing these worksheets, students should be able to:

1. Translate a research question into measurable quantities.
2. Distinguish direct measurements from calculated quantities.
3. Define dependent variables operationally.
4. Select a scientifically appropriate measurement range.
5. Choose the number and spacing of experimental conditions.
6. Distinguish experimental conditions from independent repeats.
7. Explain the purpose of preliminary experiments.
8. Identify the useful working range of analytical instruments.
9. Distinguish interpolation from extrapolation.
10. Design suitable calibration standards.
11. Select analytical techniques based on chemical principles.
12. Compare sensitivity, selectivity, accuracy, precision and practicality.
13. Anticipate measurement uncertainty before collecting data.
14. Plan appropriate controls and independent repeats.
15. Construct and justify a complete measurement strategy.

The worksheets progress from basic concepts to independent research design.

Research Question → Measurement → Technique → Range → Data → Conclusion

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Section A — From Research Question to Measurement

Worksheet 1 — What Exactly Are We Measuring?

A student proposes the research question:

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

Question 1

Identify the independent variable.

Question 2

Identify the dependent variable.

Question 3

The student writes:

"I will measure the reaction rate."

Explain why this statement is incomplete.

Question 4

Suggest one measurable quantity that could be used to determine reaction rate.

Question 5

Name one suitable measuring instrument.

Research thinking

Complete:

What I want to know ≠ necessarily what I measure _____

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Worksheet 2 — Direct vs Indirect Measurements

Classify each quantity as:

D — Direct measurement

I — Indirect or calculated quantity

Quantity	**D / I**
Mass recorded using a balance	_____
Concentration calculated using $c = n/V$	_____
Temperature recorded using a probe	_____
Percentage recovery	_____
Absorbance recorded using a spectrophotometer	_____
Initial rate calculated from a graph	_____
Volume delivered from a burette, calculated from two readings	_____
Time recorded using a stopwatch	_____

Question 1

Why does a calculated quantity depend on the quality of the original measurements?

Question 2

Give one example of a calculated chemical quantity and the measurements required to determine it.

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Worksheet 3 — Operational Definitions

Consider the research question:

How does hydrochloric acid concentration affect reaction rate?

Three students propose different methods.

Student A

"Measure how fast the reaction happens."

Student B

"Measure the time taken to collect 20.0 cm^3 of hydrogen gas."

Student C

"Measure hydrogen gas volume at regular time intervals and determine the initial gradient of the gas-volume–time graph."

Question 1

Which student provides the least precise operational definition?

Student _____

Question 2

Which student proposes a method for estimating the initial gas-production rate?

Student _____

Question 3

Why are the methods proposed by Students B and C not necessarily equivalent?

_____

_____

Question 4

Write an operational definition for the dependent variable in the following research question:

How does the concentration of a coloured solution affect its absorbance?

_____

_____

_____

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Worksheet 4 — Does the Measurement Answer the Question?

A student investigates:

How does the number of liquid–liquid extraction steps affect percentage recovery of compound X?

The student proposes measuring only the volume of the organic layer.

Question 1

Is the proposed measurement sufficient?

☐ Yes

☐ No

Question 2

Explain why.

Question 3

What additional chemical quantity must be determined?

Question 4

Complete:

$$\%\ \text{recovery} = \frac{\qquad\qquad}{\qquad\qquad} \times 100$$

Question 5

Suggest one analytical technique that might be suitable for determining the amount of compound X recovered.

State an assumption about compound X that makes your chosen technique suitable.

Section B — Episode 22: Choosing the Right Measurement Range

Worksheet 5 — What Is a Measurement Range?

A student investigates the effect of temperature on reaction rate using:

$$20, 30, 40, 50, 60^{\circ}\text{C}$$

Question 1

State the minimum temperature.

Question 2

State the maximum temperature.

Question 3

Calculate the total temperature range.

Question 4

How many experimental conditions are investigated?

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