LearningSparks®
Education Services

Pre-IB Chemical Research Skills Programme

Chemical Research Skills

A Skills-Building Programme for Independent Chemical Investigation

Module 5 | Worksheets

Student Practice & Application

Module Focus

- Planning a chemical reaction investigation
- Understanding and controlling reaction conditions
- Monitoring the progress of a reaction
- Determining reaction rate (e.g. initial rate method)
- Analysing and interpreting data to draw a valid conclusion

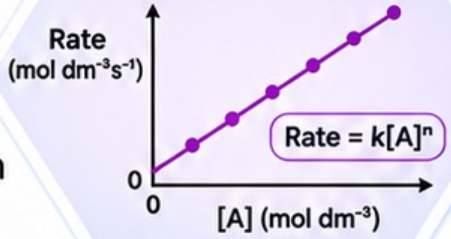


Key Skill

Following a Reaction Using UV-Vis

- Track change in absorbance
- Relate to concentration
- Determine the rate of reaction

Initial Rate Method





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Module 5 — Student Worksheets
From Calibration to Unknown Concentration
Calibration Quality, Unknowns & Defensible Results
Student: _____ **Date:** _____
Module goal: Learn not only how to calculate an unknown concentration, but how to decide whether the result is scientifically trustworthy.

Worksheet 1 — Can We Trust the Calibration?
Two calibration datasets are shown below.
Dataset A

c/ mol dm⁻³	Absorbance
0.020	0.124
0.040	0.249
0.060	0.371
0.080	0.498
0.100	0.622

Dataset B

c/ mol dm⁻³	Absorbance
0.020	0.124
0.040	0.249
0.060	0.371
0.080	**0.912**
0.100	0.622

Question 1
Which dataset appears more internally consistent?
Dataset _____
Question 2
Which concentration in Dataset B deserves investigation?
C =_____mol dm^{-3}
Question 3
Should this point immediately be deleted?
☐ Yes
☐ No
Explain:

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Question 4

Suggest three possible reasons for the unusual value.

1. _____
2. _____
3. _____

Worksheet 2 — Investigate Before You Delete

A standard is expected to give an absorbance near 0.50.

The first measurement gives:

$$A = 0.912$$

What should the researcher do?

Number the following in a sensible order.

☐ Delete the point from the graph

☐ Check the cuvette for contamination/fingerprints/bubbles

☐ Check that the correct sample was measured

☐ Repeat the measurement

☐ Check the preparation and dilution records

☐ Reprepare the standard if necessary

Complete

An unusual result should first be _____ rather than automatically _____.

Researcher thinking

Why is:

"I deleted it because it made my R^2 lower"

not a scientifically sufficient justification?

_____

_____

_____

Worksheet 3 — Random Variation or Systematic Problem?

Classify each situation as most likely involving:

Random variation • Systematic error • Neither/insufficient information

Situation	Classification
Repeated absorbances: 0.491, 0.498, 0.494	_____
Every concentration was calculated using the wrong molar mass	_____
Balance always reads 0.020 g too high	_____
One reading differs slightly from the others	_____
Wrong blank used for every measurement	_____

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Situation	Classification
Student spills the entire sample	_____

Complete

Random variation tends to cause measurements to:

Systematic error tends to cause measurements to:

Question

Why may repeating a measurement fail to detect or correct a systematic error?

Worksheet 4 — Precision Does Not Guarantee Accuracy

Three measurements of an unknown give:

$$0.521,\ 0.522,\ 0.521$$

Question 1

Are these measurements precise?

☐ Yes

☐ No

Explain:

Question 2

The student later discovers that an inappropriate blank was used.

Can the results still be precise?

☐ Yes

☐ No

Can they still be inaccurate?

☐ Yes

☐ No

Complete

High precision ≠ high _____

Explain

How can measurements be highly precise but inaccurate?

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Worksheet 5 — What Does R^2Tell Us?

Consider:

$$R^2 = 0.9997$$

Tick the statements that are justified.

☐ The data show a very strong fit to the linear regression.

☐ All standard concentrations must be correct.

☐ The experiment must be accurate.

☐ The blank must have been appropriate.

☐ The data conform closely to the fitted linear model.

☐ There cannot be systematic error.

Complete

R^2tells us about the _____ of the data to the fitted model.

It does **not** independently prove the _____ of the entire experiment.

Final statement

High R^2 ≠ guaranteed _____

Worksheet 6 — The Beautiful but Wrong Calibration

A student prepares five standards.

Unfortunately, every actual concentration is **10% lower** than the concentration written on its label.

The student still obtains:

$$R^2 = 0.9999$$

Question 1

Can the calibration still look beautifully linear?

☐ Yes

☐ No

Question 2

Are the x-axis concentration values correct?

☐ Yes

☐ No

Question 3

Can an unknown concentration calculated from this calibration be systematically incorrect?

☐ Yes

☐ No

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Complete

Mathematical quality ≠ chemical _____

Worksheet 7 — Calculate, Then Evaluate

Calibration:

$$\boxed{A = 6.24c + 0.004}$$

Unknown:

$$A = 0.441$$

Part A — Calculate

$$0.441 = 6.24c + 0.004$$

0.441-0.004 = _____

C =_____/6.24

C =_____ mol dm^{-3}

Part B — Evaluate

Calibration range:

$$0.020 - 0.100 \text{ mol dm}^{-3}$$

Does the calculated result lie inside the range?

☐ Yes

☐ No

Therefore this is:

☐ interpolation

☐ extrapolation

Part C

Why should this check be performed **after calculating** the unknown?

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