Summary

Measurement and data processing

Subject	Year	Start date	Duration
Chemistry	IB2	Week 2, January	4 weeks 10 hours

Course Part

Core and Higher level

Description

All measurement has a limit of precision and accuracy, and this must be taken into account when evaluating experimental results. Although spectroscopic characterisation techniques form the backbone of structural identification of compounds, typically no single technique results in a full structural identification of a molecule.

Inquiry & Purpose

Inquiry / Higher Order Questions

Type	Inquiry Questions
Concept-based	To what extent is mathematics simply the science of patterns?

Curriculum

Aims

Develop an ability to analyse, evaluate and synthesize scientific information

Develop and apply 21st century communication skills in the study of science

Develop an appreciation of the possibilities and limitations of science and technology

Develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge

Objectives

Demonstrate knowledge and understanding of

facts, concepts, and terminology

Apply

methodologies and techniques

Formulate, analyse and evaluate

scientific explanations

Syllabus Content

Core

11. Measurement and data processing

11.1 Uncertainties and errors in measurement and results

Nature of science:

Making quantitative measurements with replicates to ensure reliability - precision, accuracy, systematic, and random errors must be interpreted through replication.

Understandings:

Qualitative data includes all non-numerical information obtained from observations not from measurement.

Quantitative data are obtained from measurements, and are always associated with random errors/uncertainties, determined by the apparatus, and by human limitations such as reaction times.

Propagation of random errors in data processing shows the impact of the uncertainties on the final result.

Experimental design and procedure usually lead to systematic errors in measurement, which cause a deviation in a particular direction.

Repeat trials and measurements will reduce random errors but not systematic errors.

Applications and skills:

Distinction between random errors and systematic errors.

Record uncertainties in all measurements as a range (±) to an appropriate precision.

Discussion of ways to reduce uncertainties in an experiment.

Propagation of uncertainties in processed data, including the use of percentage uncertainties.

Discussion of systematic errors in all experimental work, their impact on the results and how they can be reduced.

Estimation of whether a particular source of error is likely to have a major or minor effect on the final result.

Calculation of percentage error when the experimental result can be compared with a theoretical or accepted result.

Distinction between accuracy and precision in evaluating results.

11.2 Graphical techniques

Nature of science:

The idea of correlation - can be tested in experiments whose results can be displayed graphically.

Understandings:

Graphical techniques are an effective means of communicating the effect of an independent variable on a dependent variable, and can lead to determination of physical quantities.

Sketched graphs have labelled but unscaled axes, and are used to show qualitative trends, such as variables that are proportional or inversely proportional.

Drawn graphs have labelled and scaled axes, and are used in quantitative measurements.

Applications and skills:

Drawing graphs of experimental results including the correct choice of axes and scale.

Interpretation of graphs in terms of the relationships of dependent and independent variables.

Production and interpretation of best-fit lines or curves through data points, including an assessment of when it can and cannot be considered as a linear function.

Calculation of quantities from graphs by measuring slope (gradient) and intercept, including appropriate units.

11.3 Spectroscopic identification of organic compounds

Nature of science:

Improvements in instrumentation - mass spectrometry, proton nuclear magnetic resonance and infrared spectroscopy have made identification and structural determination of compounds routine.

Models are developed to explain certain phenomena that may not be observable—for example, spectra are based on the bond vibration model.

Understandings:

The degree of unsaturation or index of hydrogen deficiency (IHD) can be used to determine from a molecular formula the number of rings or multiple bonds in a molecule.

Mass spectrometry (MS), proton nuclear magnetic resonance spectroscopy (^{1}H NMR) and infrared spectroscopy (IR) are techniques that can be used to help identify compounds and to determine their structure.

Applications and skills:

Determination of the IHD from a molecular formula.

Deduction of information about the structural features of a compound from percentage composition data, MS, ^{1}H NMR or IR.

Additional higher level

21. Measurement and analysis

21.1 Spectroscopic identification of organic compounds

Nature of science:

Improvements in modern instrumentation - advances in spectroscopic techniques (IR, ^{1}H NMR and MS) have resulted in detailed knowledge of the structure of compounds.

Understandings:

Structural identification of compounds involves several different analytical techniques including IR, ^{1}H NMR and MS.

In a high resolution ^{1}H NMR spectrum, single peaks present in low resolution can split into further clusters of peaks.

The structural technique of single crystal X-ray crystallography can be used to identify the bond lengths and bond angles of crystalline compounds.

Applications and skills:

Explanation of the use of tetramethylsilane (TMS) as the reference standard.

Deduction of the structure of a compound given information from a range of analytical characterization techniques (X-ray crystallography, IR, ^{1}H NMR and MS).

ATL Skills

Approaches to Learning

Thinking

- In this unit, we will

  ask open questions

  build on a specific prior task

  help students to make their thinking more visible (for example, by using a strategy such as a thinking routine)

  require students to take an unfamiliar viewpoint into account when formulating arguments

  ask questions that required the use of knowledge from a different subject from the one you are teaching

  make a link to TOK

Research

- In this unit, we will

  require students to formulate/construct a focused research question (either in class or in a homework assignment)

  require students to practise effective online search skills (for example, use of Booleans and search limiters)

Developing IB Learners

Learner Profile

Inquirers

Knowledgeable