2016 Suite

OCR
Oxford Cambridge and RSA

Cambridge TECHNICALS LEVEL 3

APPLIED SCIENCE

Cambridge TECHNICALS 2016

Unit 3

Scientific analysis and reporting

Y/507/6150

Guided learning hours: 120

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ocr.org.uk/science

LEVEL 3

UNIT 3: Scientific analysis and reporting

Y/507/6150

Guided learning hours:120

Essential resources required for this unit: Scientific calculator, access to science in the media.

This unit is externally assessed by an OCR set and marked examination.

UNIT AIM

The techniques presented in this unit underpin the work of scientists in the collection, analysis and presentation of data and information. The unit will develop your knowledge and understanding of a range of useful analytical techniques that can be applied in experimental and investigative settings. Techniques used in scientific experimentation and analysis must be valid, require the accurate and careful gathering of sufficient data and ultimately its interpretation and reporting.

This unit will build on the laboratory techniques from Unit 2 by adapting and extending these according to requirements and applications.

Scientists must produce reports on their scientific investigations designed to meet the needs of specific audiences. Their findings may be further reported on in the public domain such as in the media.

This unit will develop a learners reporting skills and evaluate those of others. They must report on the scientific techniques they have used, methods designed and selected to analyse the data they have collected and appropriate formats to present their findings.

TEACHING CONTENT

The teaching content in every unit states what has to be taught to ensure that learners are able to access the highest grades.
Anything which follows an i.e. details what must be taught as part of that area of content. Anything which follows an e.g. is illustrative.

For externally assessed units, where the content contains i.e. and e.g. under specific areas of content, the following rules will be adhered to when we set questions for an exam:

- a direct question may be asked about unit content which follows an i.e.
- where unit content is shown as an e.g. a direct question will not be asked about that example.

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
1. Be able to use mathematical techniques to analyse data	1.1 Application of basic arithmetic techniques, i.e.: • finding a mean, median, mode • correct rounding of values • use of appropriate SI unit • represent quantities in standard form • convert numbers between fractional, decimal and standard form • appropriate value of significant figures	• SI base quantities and their units: ○ length: metre (m) ○ mass: kilogram (kg) ○ time: second (s) ○ electric current: ampere (A) ○ temperature: Kelvin (K) ○ amount of substance: mole (mol) ○ luminosity: candela (cd) • derived units of SI base units e.g. ○ density (kg m^{-3}) ○ velocity (m s^{-1}) • appropriate use of significant figures and decimal places in scientific calculations.
	1.2 Use of simple mathematical techniques, i.e.: • calculating percentage error • percentage yield • substitution in an equation • calculation of surface area and volume	calculate: • percentage error in an experimentally determined value percentage error = $\frac{(\text{experimental value} - \text{accepted value}) \times 100}{\text{accepted value}}$ • percentage yield of a chemical reaction percentage yield = $\frac{\text{amount of product obtained} \times 100}{\text{expected amount of product}}$ • surface area of sphere = $4\pi r^2$ • volume of sphere = $4/3\ \pi r^3$ • volume of cylinder = $\pi r^2 h$ **Learners will not be expected to recall the equations**

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
	1.3 Complex mathematical techniques, i.e.: • calculating rate • changing the subject of an equation • geometric progression (serial dilutions) • quantitative assessment of uncertainty • quantitative assessment of error • calculating variance and standard deviation	• calculate the rate of change from a linear graph • use the slope of a tangent to a curve as a measure of the rate of change • serial dilution, to include: ○ understand that a constant dilution factor provides a geometric progression of concentrations ○ a ten-fold dilution for each step (e.g. concentrations in mol dm^{-3} going from 1, 0.1, 0.01 etc) is a logarithmic dilution • uncertainty and error to include: ○ uncertainty of an experimentally determined value is the interval within which the true value can be expected to lie e.g. the mass is 20g ±0.01g ○ uncertainty in a measurement reading is ± half the smallest scale division e.g. the uncertainty in a burette reading is ± 0.05 cm^3 ○ percentage error in measurements percentage error in measurements = $\frac{\text{uncertainty in measurement} \times 100}{\text{measurement reading}}$ • calculate variance using: $s^2 = \frac{\sum(X-\bar{X})^2}{N-1}$ where s^2 = sample variance $\bar{X}$ = sample mean X = term in data set N = sample size Σ = sum Standard deviation = $\sqrt{}$variance **Learners will not be expected to recall the equations**

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
2. Be able to use graphical techniques to analyse data	2.1 Appropriate choice of graph, chart or diagram related to data, i.e.: • scatter graph • line graph • bar chart • histogram • pie chart • kite diagram	• use appropriate scales and axes and plot the data accurately
	2.2 Draw linear and non-linear graphs from data i.e.: • continuous • discontinuous	
	2.3 Apply accuracy and precision to a graph, i.e.: • use of range bars • identification of outliers	• draw and use of lines of best fit • how range bars signify the range of results for a data point • identification of outliers when plotted on a graph
	2.4 Interpreting data through graphs i.e.: • find values by interpolation and extrapolation • determine intercepts for graphs • calculating gradient of a line	• identify main trends and patterns in the data • correlation to include examples of: ○ positive correlation ○ negative correlation ○ no correlation • find values by interpolation to include reading off a value from a calibration curve • find values by extrapolation of a straight line graph or a curve • determine intercepts for straight line graphs • calculate the gradient of ○ a straight line ○ a curve at a particular point

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
3. Be able to use keys for analysis	3.1 To use and construct a key to identify collected specimens	• use of dichotomous keys and identification charts: ○ they can both be based on external and/or internal physical features of the organisms collected ○ for both, advantages and disadvantages of using external physical features only ○ can be presented as a table or list with pairs of statements (called couplets) or as a branching tree diagram/model/chart
	3.2 Use a key to compare the quality of primary data to secondary data	• judge the quality of data collected to enhance the interpretation of a key, to include: ○ gases in the atmosphere ○ chemical composition of solutions such as purity of freshwater ○ presence of indicator species
	3.3 Classification system – rationale for classification of living things	• classification aims to give consistency by the use of accepted naming conventions and the simplification of scientific names • levels of classification are: kingdom, phylum, class, order, family, genus, and species • the five kingdoms are: Prokaryotae, Protoctista, Fungi, Plantae, Animalia
	3.4 Binomial nomenclature	• binomial nomenclature is the two-naming system used for all organisms • each organism has a formal name which is universally recognised i.e. the generic name (genus) and specific name (species) • the generic and specific names are written in Latin and are printed in italics or underlined e.g. *Homo sapiens*

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
4. Be able to analyse and evaluate the quality of data	4.1 Define and apply terms commonly used in experimental analysis and evaluation	• definition and application of terms to include: ○ accuracy ○ precision ○ repeatability ○ reproducibility ○ uncertainty ○ validity **Refer to language of measurement in context for Physics, Chemistry or Biology, based on ASE Language of Measurement**
	4.2 Discuss the quality of data, i.e.: • identify relationships between variables • level of uncertainty of data, including anomalous results • sources of error • instrument error • measurement error • systematic error • random error • accuracy of measurements • precision • range and interval • repeatability • reproducibility	• comparison of quantitative vs qualitative data • acceptable tolerance of data collected e.g. result was within 5% of given value or expected value was 120 ± 5 units • sources of error often overlap, to include: ○ instrument error (the readings are not actual values and may stem from mathematical inaccuracy of the equipment) ○ measurement error (the difference between the true value of a quantity and its measured value, characterised as systematic or random errors) ○ systematic error (repeatable and often linked to malfunctioning, uncalibrated equipment or poor experimental design) ○ random error (due to chance, generally expected, cannot be predicted and is not replicated when repeating an experiment) • anomalous data can readily be seen in tables and graphs data and do not fit in with the overall pattern, trend or range of data collected

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
5. Be able to draw justified conclusions from data	5.1 Conclusion given and justified, i.e.: • comparison between primary and secondary sources of information • identification of conflicting evidence • further evidence required to make the conclusion more secure	• reasons for comparing experimental or primary results with secondary data • comparisons between results and secondary data and reasons for similarities or differences • explicit links between the description of the pattern/trend and the data from which it is derived • explanations of trends/patterns supported by scientific evidence/theory • secondary data or repeats of experiments may provide conflicting evidence • the improvement of secure/confident conclusions, to include: ○ consideration of anomalies ○ modifying the experimental design, such as use of controls, more samples/replicates, statistical analysis
6. Be able to use modified, extended or combined laboratory techniques in analytical procedures	6.1 Modify microscopic analytical techniques according to need, i.e.: • Use of alternative staining procedures in microscopy • Preparation of permanent slides	• reasons to modify laboratory techniques for microscopy, to include: ○ size of cells and organelles ○ lack of natural pigmentation or colour ○ denaturation/breakdown of cell contents if not preserved or fixed ○ improvement of microscopic images gives greater visualisation of cell contents • different stains can reveal cellular components, to include: ○ methylene blue ○ iodine • preparation of permanent microscope slides, to include: ○ stopping reactions / killing living cells (e.g. alcohol or osmic acid) ○ fixing cell contents (alcohol)

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
		○ staining to enhance specific cell contents ○ dehydration to remove water from cells and replace with alcohol ○ clearing of substances to make staining easily visible (xylene) ○ mounting specimen on microscope slide (saline-based, buffer solution) ○ labelling of slide to indicate sample type, source, stain used and date
	6.2 Adaptation of chromatographic techniques, i.e.: • Use of column chromatography and thin-layer chromatography (TLC) as a preparative and quantitative technique • Use of TLC as a quantitative technique by elution or densitometry	**Knowledge of Unit 2 (2.1) is required** • uses of column chromatography to include: ○ separating substances in a mixture ○ isolating single compounds from a mixture • the main principles of column chromatography to include: ○ the stationary phase is silica gel packed in a column ○ the mobile phase or eluant is the solvent or mixture of solvents • uses of TLC as a quantitative process to include two techniques: ○ Spots can be scraped from a TLC plate, extracted with a solvent and placed in a spectrophotometer to measure how much light is absorbed ○ Densitometry is a modern technique involving scanning the TLC plate with light of a particular wavelength range so that the optical density of the spots on the plate can be measured • comparison of column chromatography with TLC

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
	6.3 Use of alternative titration techniques, i.e.: • Precipitation titrations, i.e. determination of chloride • Redox titrations, i.e. standards to include potassium manganate (VII), iodine solution, sodium thiosulfate • Complexometric techniques i.e. EDTA	**Knowledge of Unit 2 (3.1) is required** • Precipitation titration to include: ○ using standard silver nitrate solution with potassium chromate indicator to determine the concentration of chloride ions in a sample e.g. in seawater • Redox titrations to include: ○ using standard potassium manganate (VII) solution to determine: - the concentration of Fe^{2+} ions in a sample e.g. in iron tablets or in moss-killer - the concentration of hydrogen peroxide e.g.in mouthwash or in contact lens solutions ○ using standard sodium thiosulfate solution with starch indicator to determine the iodine number in fats and oils ○ using standard iodine solution with starch indicator e.g. to determine the vitamin C content in orange juice or fruits and vegetables • Complexometric titrations using standard EDTA with Eriochrome Black T as indicator to determine the concentration of metal ions e.g. Ca^{2+} ions in hard water • For each type of titration learners should know: ○ how to determine the end point ○ how to use experimental results to determine the required concentration **Recall of specific ionic equations for the reactions involved and/or relevant reacting ratios will not be required**

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
	6.4 Select and use analytical techniques with improved specificity • Test for cations i.e. thiocyanate for iron (III) and 1,10–phenanthroline for iron (II) • Adaptation as quantitative techniques i.e.: iron(III) by colorimetry (thiocyanate) and iron(II) by spectrophotometry	**Knowledge of Unit 2 (5.1) is required** • test for Fe^{3+} ions: ○ when thiocyanate ions (e,g. as potassium thiocyanate) is added to a solution containing Fe^{3+} ions an intense blood red colour is seen. ○ the test is very sensitive because the colour is very intense • test for Fe^{2+} ions: ○ when 1,10–phenanthroline is added to a solution containing Fe^{2+} ions a red-orange colour is seen. • quantitative analysis of Fe^{3+} ions to include: ○ prepare known concentrations of solutions which contain $Fe^{3+}(aq)$ (usually iron (III) chloride) ○ add the same amount of potassium thiocyanate to each solution ○ measure absorbance of each solution using a colorimeter ○ plot a calibration curve of absorbance against concentration ○ add potassium thiocyanate to the test solution and measure the absorbance ○ use the calibration curve to read off the concentration of the test solution • quantitative analysis of Fe^{2+} ions to include: ○ prepare known concentrations of solutions which contain $Fe^{2+}(aq)$ (usually iron (II) sulfate) ○ add the same amount of 1, 10–phenanthroline to each solution ○ measure absorbance of each solution using a spectrophotometer ○

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
		○ plot a calibration curve of absorbance against concentration ○ add 1, 10–phenanthroline to the test solution and measure the absorbance ○ use the calibration curve to read off the concentration of the test solution
	6.5 Use of a combination of techniques for bacterial identification, i.e.: • Colony morphology • Staining techniques • Growth and behaviour on differential, selective and enriched media	**Knowledge of Unit 2 is required** • morphology based on appearance of bacterial colonies, to include: ○ colour ○ shape ○ size • staining of colonies for identification purposes, to include: ○ gram staining (positive or negative). The two stains used are crystal violet and fuchsin or safranin • reasons for using differential, selective and enriched media
7. Be able to record, report on and review scientific analyses	7.1 Methods of recording data, i.e.: • Notebooks, logbooks • Tables • Graphs • Photographs and sketches • Video • Audio • 3D representations, e.g. of crime scenes • Modelling, e.g. GIS geographical information system for terrain, fossil organisms	• the most appropriate way to record data for different types investigations and analyses • advantages and disadvantages of different types of data records
	7.2 Reporting data, findings and other scientific information, i.e.: • Reporting to a chosen audience (peers, public, scientific community) • Reporting by the scientific media i.e. public information scientists; science journalists	• data are reported by a range of public information scientists, to include: ○ universities ○ government agencies, e.g. NHS ○ forensic science agencies ○ research organisations, e.g. agriculture, pharmaceutical, and medical ○ science and technology companies ○ museums

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
		• different audiences have specific requirements for level of detail, overall presentation of data and use of scientific terminology • examples of audiences to include: ○ peers (students, scientists, health professionals) ○ members of the public ○ scientific community (technicians, researchers) • data reported by science journalists, to include: ○ scientific books ○ newspaper articles ○ magazine articles ○ TV programmes ○ internet news sites ○ Wikis ○ vlogs ○ blogs • differences between the reporting of science by public information scientists and science journalists
	7.3 Evaluating the reporting data, findings and other scientific information, i.e.: • Status and affiliation of author(s) • Publication or information source in which data reported • Nature of data and scientific findings reported, i.e. validity of study and data, accuracy, quality of science explanations • Quality of reporting, i.e. clarity, conciseness, appropriate to intended audience	• key features of reporting primary and secondary data • the importance of peer review of articles for publication and for the scientific community • compare and evaluate the quality of data and reports produced by peers and via the scientific media

LEARNING OUTCOME (LO) WEIGHTINGS

Each learning outcome in this unit has been given a percentage weighting. This reflects the size and demand of the content you need to cover and its contribution to the overall understanding of this unit. See table below:

LO1	10-20%
LO2	10-20%
LO3	10-20%
LO4	10-20%
LO5	10-20%
LO6	10-20%
LO7	5-15%

ASSESSMENT GUIDANCE

All Learning Outcomes are assessed through externally set written examination papers, worth a maximum of 100 marks and 2 hours in duration.

This unit is externally examined. Teachers are advised to obtain sample examination papers available from the OCR website. Examination papers typically contain six questions covering the learning outcomes presented in the unit specification. Problems are presented to learners using a range of styles, including short answer, calculation, fill the blanks, matching, true/false, longer essay type questions etc. Problems are presented in a scientific context.

To find out more
ocr.org.uk/science
or call our Customer Contact Centre on **02476 851509**

Alternatively, you can email us on **vocational.qualifications@ocr.org.uk**

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