Unit title: Analytical Chemistry

Unit code: **M/601/0410**

QCF level: **5**

Credit value: **15**

Aim

The unit enables learners to understand and perform some key processes involved in analytical chemistry and to gain practical skills in undertaking extended practical investigations.

Unit abstract

Chemical analysis plays a key role in the operation of industrial, biomedical and forensic science. This unit will provide the scientific principles, concepts and skills required to understand and perform some key processes involved in analytical chemistry. The unit covers a wide range of classical and modern analytical techniques, using a practical approach, whilst at the same time building in relevant theoretical concepts. The overall aim of this unit is to provide learners with opportunities to carry out extended investigations in a small group. The investigations should involve extended practical exercises or adopt a more open-ended project approach.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand how the analytical process is used systematically to prepare for analyses

2 Be able to undertake analytical separations

3 Be able to undertake quantitative analyses

4 Be able to apply spectroscopic techniques of analysis.

Unit content

1 **Understand how the analytical process is used systematically to prepare for analyses**

Define the problem: type of analytical process e.g. separation, quantitative analysis, spectroscopic analysis

Prepare for analysis: literature survey

Analytical method: choice of method; sampling; preliminary sample treatment; separation of analyte; final method of analysis; method validation

Evaluate results: data collection, data manipulation; critical analysis of results; presentation of results in an appropriate format

2 **Be able to undertake analytical separations**

Method selection: selected technique based on nature of mixture components; type of contaminants; quantities to be separated; volatility/solubility of components

Selected techniques: solvent extraction; principles; selectivity based on pH control and complexation; methods of extraction; chromatography: principles and application of partition and adsorption as applied to separation of samples using paper, thin layer, column, gas and high performance chromatography; GLC and HPLC (injection, columns, stationary and mobile phases, temperature control, detectors, retention time, quantitative analysis using internal standards, standard addition); ion exchange (types of ion exchange resin, kinetics of exchange, selectivity of resins, use in separation and concentration of analyte); electrophoresis (principles of zone electrophoresis as applied to separation of samples using media of paper and/or gel, effect of pH, temperature, ion strength, electro-osmosis)

Conditions: choice of stationary phase; choice of mobile phase; detection methods; temperature settings; selection of internal standards

Calibration: calibrate equipment relative to known standards

Undertake separations: separate mixtures; evaluate results; report findings

3 **Be able to undertake quantitative analyses**

Titrimetry: acid-base; redox; complexometric; precipitation; potentiometric

Gravimetry: reaction between analyte and reagent in solution to give sparingly soluble salts; filtration; drying; ignition; weighing of precipitates

Appropriateness of techniques: justify selection of method

Calibration: calibrate equipment relative to known standards

Accuracy and precision: differentiate between accuracy and precision; determine parameters from measurements

Process data: data collection and manipulation; error analysis; evaluation of results

4 **Be able to apply spectroscopic techniques of analysis**

Spectroscopic techniques: atomic spectroscopy (flame emission, instrumentation, interferences and applications); atomic absorption (instrumentation, interferences and applications); molecular spectrometry (visible and ultraviolet, infrared, nuclear magnetic resonance, mass spectrometry, principles, instrumentation, applications of each technique); Beer-Lambert Law; visible and ultraviolet (electronic transitions in molecules, chromophores, modification of chromophoric absorption by surrounding molecular structure, solvent effect, use in determining concentration); infrared (fundamental bands, characteristic group wave numbers, overtones, combination bands); nuclear magnetic resonance (spin transitions and resonance, chemical shift, spin/spin coupling, first order splitting pattern); mass spectrometry (molecular ion, base peak, molecular fragmentation processes, use of high resolution measurements)

Use of combined techniques in structure elucidation: appropriate combination of spectroscopic techniques to confirm structure of simple unknowns or molecular fragments

Calculation of results of analyses: reacting masses and volume; concentration and dilution of a solution; percentage composition

Statistical methods: true result; accuracy; precision; spread; deviation; standard deviation; variance

Errors: determinate and indeterminate; reliability of measurements; evaluation of data

Confidence limits: in terms of the final result

Reporting results: tables; charts; graphs and narrative created by hand and computer packages; verbal reports

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Understand how the analytical process is used systematically to prepare for analyses	1.1 define the problem 1.2 undertake a literary search to prepare for analysis 1.3 explain the methods of sampling, separation and validation of the analytical method 1.4 evaluate results and present in an appropriate format
LO2 Be able to undertake analytical separations	2.1 select a method to separate or concentrate the sample 2.2 explain the appropriateness of the selected technique to the selected analysis 2.3 identify the conditions appropriate to the analysis 2.4 calibrate equipment as appropriate and safely undertake analytical separations
LO3 Be able to undertake quantitative analyses	3.1 use titrimetric and gavimetric methods to analyse a sample, using safe practices 3.2 explain the appropriateness of the selected techniques to the selected analyses 3.3 calibrate equipment as appropriate and record measurements to specified accuracy and precision 3.4 process experimental data
LO4 Be able to apply spectroscopic techniques of analysis	4.1 use spectroscopic techniques to analyse samples and interpret results 4.2 select combined techniques to elucidate proposed structures 4.3 calculate results using appropriate mathematical/statistical methods to process results 4.4 identify errors in the methods used and determine the confidence limits of the final result 4.5 report the results of analyses appropriately

Guidance

Links

This unit has particular links with the following units within this qualification:

- *Unit reference number H/601/0355: Chemical Laboratory Techniques*
- *Unit reference number F/601/0220: Analysis of Scientific Data and Information*
- *Unit reference number L/601/0222: Laboratory Management*
- *Unit reference number J/601/0297: Statistics for Experimental Design*.

Essential requirements

Delivery

The classical techniques of solvent extraction, gravimetry and titrimetry must be included. Automatic titrimetry, detection of end points by potentiometric and conductometric means and the use of redox, precipitation and complexometric techniques could be used.

It is anticipated that learners will work in small groups acting as a project team. They will make decisions about the work to be carried out, the literature searches required, the timescale, and the processing and presentation of the results. Practical tasks must include risk analyses consistent with COSHH guidelines.

Assessment

Assignments must be designed to allow investigation rather than being a prescriptive list of the steps required. Learners will then decide how to approach and complete the analytical problem.

The outcome of these assignments will be a number of reports or presentations, which will provide evidence that learners have met the criteria. The reports may be written or verbal, or presented in other appropriate formats. If group reports are produced, it must be clear that each team member has met the criteria on an individual basis for their contribution to the overall process.

Resources

This unit requires access to a range of classical and spectroscopic, chromatographic and electrophoretic instrumentation.

Ideally, learners should have the opportunity to use all the identified analytical techniques. However all learners must use infrared, ultraviolet/visible, nuclear magnetic resonance and gas and liquid chromatography and any three of the following: flame emission, atomic absorption and mass spectrometers, ion exchange and paper/gel electrophoresis. The theoretical principles of all techniques must be studied by all learners.

Learners will need access to a wide range of analytical equipment. It is important that learners develop an understanding of the analytical process, rather than mastering every technique. Where centres do not possess all of the necessary equipment, they could make arrangements to use instruments in industry or form links with neighbouring educational establishments.

Employer engagement and vocational contexts

Learners would benefit from visits to industrial laboratories to observe practical analytical investigations in operation.