Changing lives through learning

Access to Higher Education Unit

This unit forms part of an Access to HE Diploma. If delivering the graded version of this unit, please refer to the Provider Handbook for details on grading descriptors and the application of these across units within your programme.

Unit Title: Chemical Spectroscopy

Graded Unit Reference Number: GA33CHE

Ungraded Unit Reference Number: UA33CHE

Module: Chemistry

Level: Three (3)

Credit Value: Three (3)

Minimum Guided Learning Hours: 30

Units barred for selection against this unit:

- **Analytical Chemistry (GA33CHE16 / UA33CHE16)**

Learning Outcome (The Learner will):	Assessment Criterion (The Learner can):
1. Understand molecular structure through interpretation of mass spectral data	1.1 Describe the role and function of the main components of a time-of-flight mass spectrometer.
	1.2 Explain how molecular structure can be determined using low-resolution mass spectral data.
	1.3 Interpret mass spectra to deduce the structure of organic molecules.
2. Understand molecular structure through interpretation of infrared spectral data	2.1 Describe the underlying principles of infrared spectroscopy.
	2.2 Explain how infrared spectral data can be used to identify features of molecular structure.
	2.3 Interpret infrared spectra to identify functional groups present in organic molecules.
3. Understand molecular structure through interpretation of nuclear magnetic resonance data	3.1 Describe the principles underlying nuclear magnetic resonance spectroscopy.

		3.2	Explain how nuclear magnetic resonance data can be used to determine features of molecular structure.
		3.3	Interpret proton (^{1}H) NMR spectra to propose the structure of organic molecules.
4.	Be able to carry out practical chemical analysis using standard laboratory techniques	4.1	Carry out paper chromatography to separate and identify components of a mixture.
		4.2	Perform qualitative tests to identify common ions, including carbonate and halide ions.
		4.3	Carry out tests to identify common laboratory gases.

Indicative Content

Learners could cover the following:

(The information below is provided for guidance only and is not mandatory)

LO1

AC1.1

Time-of-flight mass spectrometer components: ionisation source (electron impact), acceleration region, drift tube (flight tube), detector.

Ionisation process: formation of positive ions through electron bombardment; production of molecular ions (M^{+}•).

Acceleration and separation: ions accelerated by electric field; separation based on mass-to-charge ratio (m/z); lighter ions travel faster.

Detection: generation of signal proportional to ion abundance; conversion into mass spectrum.

Vacuum conditions: importance of reducing collisions for accurate ion flight.

AC1.2

Mass spectra features: m/z values, relative abundance, molecular ion peak, base peak.

Determining molecular mass: identification of M^{+} peak.

Isotopic patterns: recognition of elements with characteristic isotope ratios (e.g., Cl, Br).

Fragmentation patterns: bond breaking, formation of stable carbocations, rearrangements.

Structural information: deduction of functional groups or substructures from fragment ions.

Limitations: low-resolution spectra and ambiguity in isomers.

AC1.3

	Spectrum interpretation: identifying molecular ion, base peak, significant fragments. **Stepwise deduction:** use of molecular mass, fragmentation pattern, and isotopic evidence. **Common fragments:** alkyl groups, alcohols, carbonyl-containing compounds. **Use of data tables:** comparison with reference spectra. **Application:** proposing full molecular structures consistent with spectral data.
LO2	AC2.1 **Principles of infrared (IR) spectroscopy:** absorption of IR radiation causing vibrational transitions in covalent bonds. **Types of vibration:** stretching (symmetric/asymmetric) and bending vibrations. **Bond polarity:** requirement for dipole moment change for absorption. **Wavenumber concept:** measurement in cm^{-1}; relationship to bond strength and mass. **IR spectrum layout:** transmittance vs wavenumber. AC2.2 **Functional group identification:** correlation of absorption bands with specific bonds. **Characteristic absorption ranges:** O–H, C=O, C–H, N–H, C=C. **Fingerprint region:** complex region (<1500 cm^{-1}) unique to compounds. **Comparative analysis:** distinguishing between similar functional groups. **Limitations:** overlapping peaks, difficulty distinguishing isomers. AC2.3 **Spectrum interpretation:** identifying key absorption peaks. **Functional group assignment:** use of data tables to match peaks. **Absence/presence:** confirming or excluding functional groups. **Examples:** alcohols, carboxylic acids, ketones, amines. **Application:** determining likely functional groups in unknown organic compounds.
LO3	AC3.1 **Principles of nuclear magnetic resonance (NMR):** interaction of nuclear spins with an external magnetic field. **Proton environments:** chemically distinct hydrogen atoms. **Resonance condition:** absorption of radiofrequency radiation.

	Chemical shift (δ): position of signals relative to standard (TMS). **Spin-spin coupling:** interaction between neighbouring protons. AC3.2 **Chemical shift interpretation:** relationship to electronic environment and functional groups. **Integration:** relative number of protons in each environment (peak area). **Splitting patterns:** n+1 rule; identification of neighbouring protons. **Multiplicity:** singlet, doublet, triplet, quartet, multiplet. **Combining data:** using chemical shift, integration, and splitting collectively. AC3.3 **Spectrum analysis:** assigning peaks to proton environments. **Structure determination:** stepwise approach combining all spectral data. **Typical chemical shift ranges:** alkyl, alkene, aromatic, aldehyde, carboxylic acid protons. **Use of reference data:** comparing with known spectra. **Application:** proposing complete structures consistent with ^{1}H NMR spectra.
LO4	AC4.1 **Paper chromatography principles:** separation based on solubility and affinity between stationary and mobile phases. **Rf values:** calculation and interpretation. **Sample preparation:** spotting technique and solvent choice. **Visualisation:** use of UV light or locating agents. **Applications:** identification of components in mixtures (e.g., inks, amino acids). AC4.2 **Qualitative ion testing:** characteristic reactions for common ions. **Carbonate ions:** reaction with acid producing CO_2; limewater test. **Halide ions:** precipitation reactions with silver nitrate (Cl^-, Br^-, I^-). **Observation skills:** colour changes, precipitate formation. **Confirmatory tests:** distinguishing between similar ions. AC4.3 **Gas testing methods:** standard laboratory tests for common gases. **Hydrogen:** ‘squeaky pop’ test.

	Oxygen: relights glowing splint. **Carbon dioxide:** turns limewater milky. **Chlorine:** bleaches damp litmus paper. **Safety considerations:** handling gases and reactive substances.