Syllabus details—Options SL and HL

SL students study the core of these options and HL students study the whole option (the core and the extension material).

Option A: Modern analytical chemistry (15/22 hours)

Analytical chemistry techniques are widely used in today's society. When teaching this option, problem solving and the need to use the information gained from one or more techniques to solve problems should be emphasized. Students should understand the chemical principles behind each analytical technique.

This option builds on some of the key ideas in both physical and organic chemistry that were introduced in the core.

Core material: A1–A7 are core material for SL and HL (15 hours).

Extension material: A8–A10 are extension material for HL only (7 hours).

A1 Analytical techniques

1 hour

	Assessment statement	Obj	Teacher's notes
A.1.1	State the reasons for using analytical techniques.	1	Uses should include structure determination, analysis of composition of substances and to determine purity.
A.1.2	State that the structure of a compound can be determined by using information from a variety of analytical techniques singularly or in combination.	1	Students should realize that information from only one technique is usually insufficient to determine or confirm a structure.

A2 Principles of spectroscopy

2 hours

	Assessment statement	Obj	Teacher's notes
A.2.1	Describe the electromagnetic spectrum.	2	X-ray, ultraviolet (UV), visible, infrared (IR), radio and microwave should be identified. Highlight the variation in wavelength, wave number, frequency and energy across the spectrum. **TOK:** The electromagnetic spectrum is a carrier of information. The nature of the information is limited by its wavelength.

	Assessment statement	Obj	Teacher's notes
A.2.2	Distinguish between *absorption* and *emission* spectra and how each is produced.	2	
A.2.3	Describe the atomic and molecular processes in which absorption of energy takes place.	2	The description should include vibrations, rotation and electronic transitions. **Aim 7:** Simulations of these processes are available.

A3 Infrared (IR) spectroscopy

3 hours

	Assessment statement	Obj	Teacher's notes
A.3.1	Describe the operating principles of a double-beam IR spectrometer.	2	A schematic diagram of a simple double-beam spectrometer is sufficient.
A.3.2	Describe how information from an IR spectrum can be used to identify bonds.	2	
A.3.3	Explain what occurs at a molecular level during the absorption of IR radiation by molecules.	3	H_2O, $–CH_2–$, SO_2 and CO_2 are suitable examples. Stress the change in bond polarity as the vibrations (stretching and bending) occur.
A.3.4	Analyse IR spectra of organic compounds.	3	Students will be assessed using examples containing up to three functional groups. The *Chemistry data booklet* contains a table of IR absorptions for some bonds in organic molecules. Students should realize that IR absorption data can be used to identify the bonds present, but not always the functional groups present.

A4 Mass spectrometry

2 hours

	Assessment statement	Obj	Teacher's notes
A.4.1	Determine the molecular mass of a compound from the molecular ion peak.	3	
A.4.2	Analyse fragmentation patterns in a mass spectrum to find the structure of a compound.	3	Examples of fragments should include: • $(M_r – 15)^+$ loss of CH_3 • $(M_r – 17)^+$ loss of OH • $(M_r – 29)^+$ loss of C_2H_5 or CHO • $(M_r – 31)^+$ loss of CH_3O • $(M_r – 45)^+$ loss of COOH.

A5 Nuclear magnetic resonance (NMR) spectroscopy

2 hours

	Assessment statement	Obj	Teacher's notes
A.5.1	Deduce the structure of a compound given information from its ^{1}H NMR spectrum.	3	Students will only be assessed on their ability to deduce the number of different hydrogen (proton) environments and the relative numbers of hydrogen atoms in each environment. They should be familiar both with a word description of a spectrum and with a diagram of a spectrum, including an integration trace. The interpretation of splitting patterns will not be assessed. **Aim 7:** Data banks could be used here.
A.5.2	Outline how NMR is used in body scanners.	2	**Aim 8:** Protons in water molecules within human cells can be detected by magnetic resonance imaging (MRI), giving a three-dimensional view of organs in the human body.

A6 Atomic absorption (AA) spectroscopy

3 hours

	Assessment statement	Obj	Teacher's notes
A.6.1	State the uses of AA spectroscopy.	1	**Aim 8:** Include uses such as the identification of metals in water, blood, soils and foods.
A.6.2	Describe the principles of atomic absorption.	2	
A.6.3	Describe the use of each of the following components of the AA spectrophotometer: fuel, atomizer, monochromatic light source, monochromatic detector and read-out.	2	
A.6.4	Determine the concentration of a solution from a calibration curve.	3	**Aim 7:** Details about the instruments used can be found on the Internet.

A7 Chromatography

2 hours

	Assessment statement	Obj	Teacher's notes
A.7.1	State the reasons for using chromatography.	1	The qualitative and quantitative aspects of chromatography should be outlined.
A.7.2	Explain that all chromatographic techniques involve adsorption on a stationary phase and partition between a stationary phase and a mobile phase.	3	Components in a mixture have different tendencies to adsorb onto a surface or dissolve in a solvent. This provides a means of separating the components of a mixture.
A.7.3	Outline the use of paper chromatography, thin-layer chromatography (TLC) and column chromatography.	2	An outline of the operation for each technique will be assessed. This should include an understanding and calculation of R_f values where relevant. Students should be aware that, in some instances, paper chromatograms may need to be developed, for example, in the separation of sugars.

HL A8 Visible and ultraviolet (UV-Vis) spectroscopy

3 hours

	Assessment statement	Obj	Teacher's notes
A.8.1	Describe the effect of different ligands on the splitting of the d orbitals in transition metal complexes.	2	The ligands should include NH_3, H_2O and Cl^-.
A.8.2	Describe the factors that affect the colour of transition metal complexes.	2	Include the identity of the metal ion (for example, Mn^{2+} or Fe^{2+}), the oxidation number of the metal (for example, for Fe, +2 or +3) and the identity of the ligand (for example, NH_3 or H_2O). These factors will be assessed only for octahedral complexes in aqueous solution.
A.8.3	State that organic molecules containing a double bond absorb UV radiation.	1	Refer to conjugated and delocalized systems, including arenes, alkenes and chlorophyll.
A.8.4	Describe the effect of the conjugation of double bonds in organic molecules on the wavelength of the absorbed light.	2	Examples should include retinol and phenolphthalein. **Aim 8:** The application of this in sun creams could be discussed.
A.8.5	Predict whether or not a particular molecule will absorb UV or visible radiation.	3	
A.8.6	Determine the concentration of a solution from a calibration curve using the Beer–Lambert law.	3	

HL A9 Nuclear magnetic resonance (NMR) spectroscopy

2 hours

	Assessment statement	Obj	Teacher's notes
A.9.1	Explain the use of tetramethylsilane (TMS) as the reference standard.	3	
A.9.2	Analyse ^{1}H NMR spectra.	3	Students should be able to interpret the following from ^{1}H NMR spectra: number of peaks, area under each peak, chemical shift and splitting patterns. Treatment of spin–spin coupling constants will not be assessed, but students should be familiar with singlets, doublets, triplets and quartets.

HL A10 Chromatography

2 hours

	Assessment statement	Obj	Teacher's notes
A.10.1	Describe the techniques of gas–liquid chromatography (GLC) and high-performance liquid chromatography (HPLC).	2	An outline of the operation for each technique will be assessed. This should include an understanding of R_t value and its dependence on other factors where relevant.
A.10.2	Deduce which chromatographic technique is most appropriate for separating the components in a particular mixture.	3	**Aim 8:** HPLC can identify compounds that are temperature-sensitive. Uses include: analysis of oil; alcoholic beverages; antioxidants, sugars and vitamins in foods; pharmaceuticals; polymers; biochemical and biotechnology research; and quality control of insecticides and herbicides. GLC can identify compounds that can vaporize without decomposing. Uses include: analysis of urine samples from athletes for drugs, underground mine gases and blood alcohol levels.