2023 VCE Chemistry EP Curriculum Map

Unit 1: Diverse Materials

Area of Study 1: How do the chemical structures of materials explain their properties and reactions?

Content Descriptor	EP Lessons in *1.1.1. Elements and the periodic table*
1.1.1.1. the definitions of elements, isotopes and ions, including appropriate notation: atomic number; mass number; and number of protons, neutrons and electrons **1.1.1.2.** the periodic table as an organisational tool to identify patterns and trends in, and relationships between, the structures (including shell and subshell electronic configurations and atomic radii) and properties (including electronegativity, first ionisation energy, metallic and non-metallic character and reactivity) of elements **1.1.1.3.** critical elements (for example, helium, phosphorus, rare-earth elements and post-transition metals and metalloids) and the importance of recycling processes for element recovery	● What are Atoms, Elements and Compounds? ● Classification of Matter ● Rutherford-Bohr Model ● Introduction to Bonding ● Atomic Number ● What are Isotopes? ● Isotope Properties ● Periodic Trends: Electronegativity ● Periodic Trends: Ionisation Energy ● Periodic Trends: Metallic Character ● Periodic Trends: Atomic Radius ● Group 15 and 16 ● History of the Atomic Model ● The Structure of an Atom ● Atomic Symbols ● Electron Configuration Revision ● Electron Configuration of Atoms ● Electron Configuration of Ions
Content Descriptor	**EP Lessons in *1.1.2. Covalent substances***
1.1.2.1. the use of Lewis (electron dot) structures, structural formulas and molecular formulas to model the following molecules: hydrogen, oxygen, chlorine, nitrogen, hydrogen chloride, carbon dioxide, water, ammonia, methane, ethane and ethene **1.1.2.2.** shapes of molecules (linear, bent, pyramidal, and tetrahedral, excluding bond angles) as determined by the repulsion of electron pairs according to valence shell electron pair repulsion (VSEPR) theory **1.1.2.3.** polar and non-polar character with reference to the shape of the molecule	● Covalent Bonding ● Electron Dot Diagrams of Atoms ● Lewis Structures of Molecules and Ions ● Development of the VSEPR Theory ● Introduction to Shapes of Molecules ● Shapes of Molecules - Extended ● The Ionic-Covalent Continuum

1.1.2.4. the relative strengths of intramolecular bonding (covalent bonding) and intermolecular forces (dispersion forces, dipole-dipole attraction and hydrogen bonding) **1.1.2.5.** physical properties of molecular substances (including melting points and boiling points and non-conduction of electricity) with reference to their structure and bonding **1.1.2.6.** the structure and bonding of diamond and graphite that explain their properties (including heat conductivity and electrical conductivity and hardness) and their suitability for diverse applications	• Polarity of Molecules • Types of Intermolecular Forces • Physical Properties of Molecular Substances • Carbon Chemistry • Covalent Network Substances • Physical Properties of Covalent Network Substances • Allotropes of Carbon • Nanomaterials
Content Descriptor	**EP Lessons in *1.1.3. Reactions of metals***
1.1.3.1. the common properties of metals (lustre, malleability, ductility, melting point, heat conductivity and electrical conductivity) with reference to the nature of metallic bonding and the existence of metallic crystals **1.1.3.2.** experimental determination of a reactivity series of metals based on their relative ability to undergo oxidation with water, acids and oxygen **1.1.3.3.** metal recycling as an example of a circular economy where metal is mined, refined, made into a product, used, disposed of via recycling and then reprocessed as the same original product or repurposed as a new product	• Metals in the Periodic Table • Metals, Non-Metals and Metalloids • Periodic Trends: Metallic Character • Metallic Substances • Physical Properties of Metallic Substances • Acid-Metal Reactions • Minerals and Rocks as Resources • Mining • Mining and Mineral Exploration
Content Descriptor	**EP Lessons in *1.1.4. Reactions of ionic compounds***
1.1.4.1. the common properties of ionic compounds (brittleness, hardness, melting point, difference in electrical conductivity in solid and molten liquid states), with reference to the nature of ionic bonding and crystal structure **1.1.4.2.** deduction of the formula and name of an ionic compound from its component ions, including polyatomic ions ($NH4+$, OH^-, $NO3^-$, $HCO3^-$, $CO32^-$, $SO42^-$ and $PO43^-$) **1.1.4.3.** the formation of ionic compounds through the transfer of electrons from metals to non-metals, and the writing of ionic compound formulas, including those containing polyatomic ions and transition metal ions **1.1.4.4.** the use of solubility tables to predict and identify precipitation reactions between ions in solution, represented by balanced full and ionic equations including the state symbols: (s), (l), (aq) and (g)	• Reaction Equations • What are Ions? • Ionic Substances • Physical Properties of Ionic Substances • Ions in Solution • Naming Ionic Compounds • Solubility in Water • Precipitation Reactions • Precipitation Equations and Descriptions

Area of Study 2: How are materials quantified and classified?

Content Descriptor	**EP Lessons in *1.2.1. Quantifying atoms and compounds***
1.2.1.1. the relative isotopic masses of isotopes of elements and their values on the scale in which the relative isotopic mass of the carbon-12 isotope is assigned a value of 12 exactly **1.2.1.2.** determination of the relative atomic mass of an element using mass spectrometry (details of instrument not required) **1.2.1.3.** Avogadro's constant as the number 6.02 × 1023 indicating the number of atoms or molecules in a mole of any substance; determination of the amount, in moles, of atoms (or molecules) in a pure sample of known mass **1.2.1.4.** determination of the molar mass of compounds, the percentage composition by mass of covalent compounds, and the empirical and molecular formula of a compound from its percentage composition by mass	Conservation of Mass (Revision) Mass Spectrometry The Mole Empirical and Molecular Formulae I Empirical and Molecular Formulae II Moles and Equations Moles and Molar Mass Moles and Balanced Equations

Content Descriptor	**EP Lessons in *1.2.2. Families of organic compounds***
1.2.2.1. the grouping of hydrocarbon compounds into families (alkanes, haloalkanes, alkenes, alcohols, carboxylic acids) based upon similarities in their physical and chemical properties, including general formulas and general uses based on their properties **1.2.2.2.** representations of organic compounds (structural formulas, semi-structural formulas) and naming according to the International Union of Pure and Applied Chemistry (IUPAC) systematic nomenclature (limited to non-cyclic compounds up to C8, and structural isomers up to C5)	● Introduction to Organic Chemistry ● Naming Alkanes ● Naming Alkynes ● Naming Alcohols ● Naming Carboxylic Acids ● Naming Esters ● Properties of Alkanes ● Properties of Alcohols

Content Descriptor	**EP Lessons in *1.2.3. Polymers and society***
1.2.3.1. the differences between addition and condensation reactions as processes for producing natural and manufactured polymers from monomers **1.2.3.2.** the formation of addition polymers by the polymerisation of alkene monomers **1.2.3.3.** the distinction between linear (thermoplastic) and cross-linked (thermosetting) addition polymers with reference to structure and properties **1.2.3.4.** the features of linear addition polymers designed for a particular purpose, including the selection of a suitable monomer (structure and properties), chain length and degree of branching	● Introduction to Polymers ● Addition Polymer Structure, Properties and Uses ● Condensation Polymer Structure, Properties & Uses ● Comparing Addition and Condensation Polymerisation ● Plastics

Unit 2: Reactions and the Natural World

Area of Study 1: How do chemicals interact with water?

Content Descriptor	**EP Lessons in *2.1.1. Water as a unique chemical***
2.1.1.1. the existence of water in all three states at Earth's surface, including the distribution and proportion of available drinking water **2.1.1.2.** explanation of the anomalous properties of $H2O$ (ice and water), with reference to hydrogen bonding: - trends in the boiling points of Group 16 hydrides; - the density of solid ice compared with liquid water at low temperatures; - specific heat capacity of water including units and symbols **2.1.1.3.** the relatively high latent heat of vaporisation of water and its impact on the regulation of the temperature of the oceans and aquatic life	• Properties of Water • Water on Earth • States of Water • Specific Heat Capacity • Specific Latent Heat
Content Descriptor	**EP Lessons in *2.1.2. Acid-base (proton transfer) reactions***
2.1.2.1. the Brønsted-Lowry theory of acids and bases, including polyprotic acids and amphiprotic species, and the writing of balanced ionic and full equations, with states, for their reactions in water **2.1.2.2.** the distinction between strong and weak acids and strong and weak bases, and between concentrated and dilute acids and bases, including common examples **2.1.2.3.** neutralisation reactions to produce salts: - reactions of acids with metals, carbonates and hydroxides, including balanced full and ionic equations, with states; - types of antacids and their use in the neutralisation of stomach acid; **2.1.2.4.** use of the logarithmic pH scale to rank solutions from most acidic to most basic; calculation of pH for strong acid and strong base solutions of known concentration using the ionic product of water (Kw at a given temperature) **2.1.2.5.** accuracy and precision in measurement as illustrated by the comparison of natural indicators, commercial indicators, and pH meters to determine the relative strengths of acidic and basic solutions **2.1.2.6.** applications of acid-base reactions in society: for example, natural acidity of rain due to dissolved $CO2$ and the distinction between the natural acidity of rain and acid rain, or the action of $CO2$ forming a weak acid in oceans and the consequences for shell growth in marine invertebrates	• Acids • Bases • Properties of Acids and Bases • pH • Kw and pOH • Reactions of Acids • Neutralisation • Metal Oxides and Hydroxides • Metal Carbonates and Hydrogen Carbonates • Factors Affecting Solubility: Acids, Bases and Complex Ions • Relative Concentrations, pH and Conductivity

Content Descriptor	**EP Lessons in *2.1.3. Redox (electron transfer) reactions***
2.1.3.1. oxidising and reducing agents, and redox reactions, including writing of balanced half and overall redox equations (including in acidic conditions), with states **2.1.3.2.** the reactivity series of metals and metal displacement reactions, including balanced redox equations, with states **2.1.3.3.** applications of redox reactions in society: for example, corrosion or the use of simple primary cells in the production of electrical energy from chemical energy	• Introduction to Oxidation-Reduction • Introduction to Oxidation-Reduction Reactions • Balancing Redox Half-Equations • Balancing Overall Redox Equations • Explaining Reactivity • Displacement Reactions • Combustion and Corrosion

Area of Study 2: How are chemicals measured and analysed?

Content Descriptor	**EP Lessons in *2.2.1. Measuring solubility and concentration***
2.2.1.1. solution concentration as a measure of the quantity of solute dissolved in a given mass or volume of solution (mol L-1, g L-1, %(m/v), %(v/v), ppm), including unit conversions **2.2.1.2.** the use of solubility tables and solubility graphs to predict experimental determination of ionic compound solubility; the effect of temperature on the solubility of a given solid, liquid or gases in water	• Solute, Solvent and Solution • Concentration • Solutions and Concentration • Other Measures of Concentration • Solubility in Water • Effect of Temperature on Solubility • Calculating Solubility • Saturated Solution Calculations • Predicting Precipitation
Content Descriptor	**EP Lessons in *2.2.2. Analysis for acids and bases***
2.2.2.1. volume-volume stoichiometry (solutions only) and application of volumetric analysis, including the use of indicators, calculations related to the preparation of standard solutions, dilution of solutions, and use of acid-base titrations (excluding back titrations) to determine the concentration of an acid or a base in a water sample	• Introduction to Titrations • Standard Solutions • Dilutions • Performing a Titration • Titration Calculations

Content Descriptor	**EP Lessons in *2.2.3. Measuring gases***
2.2.3.1. CO2, CH4 and H2O as three of the major gases that contribute to the natural and enhanced greenhouse effects due to their ability to absorb infrared radiation **2.2.3.2.** the definitions of gas pressure and standard laboratory conditions (SLC) at 25 °C and 100 kPa **2.2.3.3.** calculations using the ideal gas equation (pV = nRT), limited to the units kPa, Pa, atm, mL, L ,°C, and K (including unit conversions) **2.2.3.5** calculations of the molar volume or molar mass of a gas produced by a chemical reaction	● Greenhouse Gases and the Enhanced Greenhouse Effect ● Introduction to Gases ● Ideal Gas Law ● Avogadro's Law and Molar Volume

Content Descriptor	**EP Lessons in *2.2.4. Analysis for salts***
2.2.4.3. molar ratio of water of hydration for an ionic compound; - the application of mass-mass stoichiometry to determine the mass present of an ionic compound; - the application of colorimetry and/or UV-visible spectroscopy, including the use of a calibration curve to determine the concentration of ions or complexes in a water or soil sample	● Mass-Mass Stoichiometry

Unit 3: Optimising Chemical Processes

Area of Study 1: What are the current and future options for supplying energy?

Content Descriptor	**EP Lessons in *3.1.1.Carbon-based fuels***
3.1.1.1. the definition of a fuel, including the distinction between fossil fuels (coal, natural gas, petrol) and biofuels (biogas, bioethanol, biodiesel) with reference to their renewability (ability of a resource to be replaced by natural processes within a relatively short period of time) **3.1.1.5.** production of bioethanol by the fermentation of glucose, C6H12O6(aq) → 2C2H5OH(l) + 2CO2(g), and subsequent distillation to produce a more sustainable transport fuel **3.1.1.6.** comparison of exothermic and endothermic reactions, with reference to bond making and bond breaking, including enthalpy changes (ΔH) measured in kJ, molar enthalpy changes measured in kJ mol-1 and enthalpy changes for mixtures measured in kJ g-1, and their representations in energy profile diagrams **3.1.1.7.** determination of limiting reactants or reagents in chemical reactions **3.1.1.8.** combustion (complete and incomplete) reactions of fuels as exothermic reactions: the writing of balanced thermochemical equations, including states, for the complete and incomplete combustion of organic molecules using experimental data and data tables **3.1.2.1.** calculations related to the application of stoichiometry to reactions involving the combustion of fuels, including mass-mass, mass-volume and volume-volume stoichiometry, to determine heat energy released, reactant and product amounts and net volume or mass of major greenhouse gases (CO2, CH4 and H2O), limited to standard laboratory conditions (SLC) at 25 °C and 100 kPa **3.1.2.4.** energy from fuels and food: - calculation of energy transformation efficiency during combustion as a percentage of chemical energy converted to useful energy; - comparison and calculations of energy values of foods containing carbohydrates, proteins and fats and oils	• Fossil Fuels • Types of Fossil Fuels • Biofuels • Comparison of Fossil Fuels and Biofuels • Use of Fuels in Society • Complete Combustion Reactions • Incomplete Combustion Reactions • Exothermic and Endothermic Processes • Stoichiometry of Fuel Combustion Reactions • Fuel Density and Measuring Energy • Fuels Revision Questions

Content Descriptor	**EP Lessons in *3.1.2. Measuring changes in chemical reactions***
3.1.2.2. the use of specific heat capacity of water to approximate the quantity of heat energy released during the combustion of a known mass of fuel and food **3.1.2.3.** the principles of solution calorimetry, including determination of calibration factor and consideration of the effects of heat loss; analysis of temperature-time graphs obtained from solution calorimetry	• Thermochemical Equations • Stoichiometry and Energy Calculations • Calorimetry • Enthalpy and Heat • Standard Enthalpy Changes: Part 1 • Standard Enthalpy Changes: Part 2 • Food as an Energy Source

Content Descriptor	**EP Lessons in *3.1.3. Primary galvanic cells and fuel cells as sources of energy***
3.1.3.1. redox reactions as simultaneous oxidation and reduction processes, and the use of oxidation numbers to identify the reducing agent, oxidising agent and conjugate redox pairs **3.1.3.2.** the writing of balanced half-equations (including states) for oxidation and reduction reactions, and the overall redox cell reaction in both acidic and basic conditions **3.1.3.3.** the common design features and general operating principles of non-rechargeable (primary) galvanic cells converting chemical energy into electrical energy, including electrode polarities and the role of the electrodes (inert and reactive) and electrolyte solutions (details of specific cells not required) **3.1.3.4.** the use and limitations of the electrochemical series in designing galvanic cells and as a tool for predicting the products of redox reactions, for deducing overall equations from redox half-equations and for determining maximum cell voltage under standard conditions **3.1.3.5.** the common design features and general operating principles of fuel cells, including the use of porous electrodes for gaseous reactants to increase cell efficiency (details of specific cells not required) **3.1.3.7.** contemporary responses to challenges and the role of innovation in the design of fuel cells to meet society's energy needs, with reference to green chemistry principles: design for energy efficiency, and use of renewable feedstocks	• Introduction to Oxidation-Reduction Reactions • Balancing Redox Half-Equations • Balancing Overall Redox Equations • Introduction to Galvanic Cells • Standard Reduction Potentials of Half-Cells • Calculating Cell Potentials for Galvanic Cells • Fuel Cells • Comparison Between Fuel Cells and Fuel Combustion • Comparison Between Fuel and Galvanic Cells Glossary • Definitions List: Fuel Cells • Definitions List: Galvanic Cells • Definitions List: Introduction to Redox • Definitions MCQ: Fuel Cells • Definitions MCQ: Galvanic Cells • Definitions MCQ: Introduction to Redox

Area of Study 2: How can the rate and yield of chemical reactions be optimised?

Content Descriptor	**EP Lessons in *3.2.1. Rates of chemical reactions***
3.2.1.1. factors affecting the frequency and success of reactant particle collisions and the rate of a chemical reaction in open and closed systems, including temperature, surface area, concentration, gas pressures, presence of a catalyst, activation energy and orientation **3.2.1.2.** the role of catalysts in increasing the rate of specific reactions, with reference to alternative reaction pathways of lower activation energies and represented using energy profile diagrams	● Rate of Reaction ● Collision Theory and Rate of Reaction ● Rate of Reaction Equations ● Factors Affecting Reaction Rates ● Maxwell-Boltzmann Distribution Curves ● Activation Energy and Energy Profiles ● Catalysts
Content Descriptor	**EP Lessons in *3.2.2. Extent of chemical reactions***
3.2.2.1. the distinction between reversible and irreversible reactions, and between rate and extent of a reaction **3.2.2.2.** the dynamic nature of homogenous equilibria involving aqueous solutions or gases, and their representation by balanced chemical or thermochemical equations (including states) and by concentration-time graphs **3.2.2.3.** the change in position of equilibrium that can occur when changes in temperature or species or volume (concentration or pressure) are applied to a system at equilibrium, and the representation of these changes using concentration-time graphs **3.2.2.4.** the application of Le Chatelier's principle to identify factors that favour the yield of a chemical reaction **3.2.2.5.** calculations involving equilibrium expressions (including units) for a closed homogeneous equilibrium system and the dependence of the equilibrium constant (K) value on the system temperature and the equation used to represent the reaction **3.2.2.6.** the reaction quotient (Q) as a quantitative measure of the extent of a chemical reaction: that is, the relative amounts of products and reactants present during a reaction at a given point in time	● Chemical Systems ● Reversible Changes ● Equilibrium ● Energetics of Reversible Reactions ● Temperature and Equilibrium ● Concentration and Equilibrium ● Pressure and Equilibrium ● Le Chatelier's Principle ● Catalysts and Equilibrium ● The Equilibrium Constant ● Calculating Equilibrium Constants ● Introduction to Equilibrium in Aqueous Systems ● Solubility Product Expressions ● Calculating Solubility Products

Content Descriptor	EP Lessons in *3.2.3. Production of chemicals using electrolysis*
3.2.3.1. the use and limitations of the electrochemical series to explain or predict the products of the electrolysis of particular chemicals, given their state (molten liquid or in aqueous solution) and the electrode materials used, including the writing of balanced equations (with states) for the reactions occurring at the anode and cathode and the overall redox reaction for the cell **3.2.3.2.** the common design features and general operating principles of commercial electrolytic cells (including, where practicable, the removal of products as they form), and the selection of suitable electrode materials, the electrolyte (including its state) and any chemical additives that result in a desired electrolysis product (details of specific cells not required) **3.2.3.3.** the common design features and general operating principles of rechargeable (secondary) cells, with reference to discharging as a galvanic cell and recharging as an electrolytic cell, including the conditions required for the cell reactions to be reversed and the electrode polarities in each mode (details of specific cells not required)	● Introduction to Electrolytic Cells and Electrolysis ● Predicting Products of Electrolysis ● Batteries

Unit 4: Designing Carbon-Based Compounds

Area of Study 1: How are organic compounds categorised and synthesised?

Content Descriptor	**EP Lessons in *4.1.1. Structure, nomenclature and properties of organic compounds***
4.1.1.1. characteristics of the carbon atom that contribute to the diversity of organic compounds formed, with reference to valence electron number, relative bond strength, relative stability of carbon bonds with other elements, degree of unsaturation, and the formation of structural isomers **4.1.1.3.** the International Union of Pure and Applied Chemistry (IUPAC) systematic naming of organic compounds up to C8, with no more than two functional groups for a molecule, limited to non-cyclic hydrocarbons, haloalkanes, primary amines, alcohols (primary, secondary and tertiary), aldehydes, ketones, carboxylic acids and non-branched esters **4.1.1.4.** trends in physical properties within homologous series (boiling point and melting point, viscosity), with reference to structure and bonding	• Introduction to Organic Chemistry • Structural Isomers • Geometric Isomers • Optical Isomers • Functional Groups Summary Naming Organic Compounds • Naming Alkanes • Molecular and Structural Formulas of Alkanes • Naming Haloalkanes • Naming Alkenes • Naming Alkynes • Naming Alcohols • Naming Ketones • Naming Aldehydes • Naming Carboxylic Acids • Naming Esters • Naming Amides • Naming Amines Properties of Organic Compounds • Properties of Alkanes • Properties of Alkenes • Properties of Alkynes • Properties of Haloalkanes • Properties of Alcohols • Properties of Carbonyl Compounds • Properties of Carboxylic Acids • Properties of Primary Amines • Properties of Esters • Properties of Amides • Physical Properties of Amino Acids

Content Descriptor	**EP Lessons in *4.1.2. Reactions of organic compounds***
4.1.2.5. organic reactions and pathways, including equations, reactants, products, reaction conditions and catalysts (specific enzymes not required): - synthesis of primary haloalkanes and primary alcohols by substitution; - addition reactions of alkenes; - the esterification between an alcohol and a carboxylic acid; - hydrolysis of esters; - pathways for the synthesis of primary amines and carboxylic acids; - transesterification of plant triglycerides using alcohols to produce biodiesel; - hydrolytic reactions of proteins, carbohydrates and fats and oils to break down large biomolecules in food to produce smaller molecules; - condensation reactions to synthesise large biologically important molecules for storage as proteins, starch, glycogen and lipids (fats and oils) **4.1.2.6.** calculations of percentage yield and atom economy of single-step or overall reaction pathways, and the advantages for society and for industry of developing chemical processes with a high atom economy **4.1.2.7.** the sustainability of the production of chemicals, with reference to the green chemistry principles of use of renewable feedstocks, catalysis and designing safer chemicals **4.2.1.1.** qualitative tests for the presence of carbon-carbon double bonds, hydroxyl and carboxyl functional groups	• Substitution Reactions of Alkanes • Addition Reactions of Alkenes • Substitution Reactions of Alcohols • Elimination Reactions of Alcohols • Oxidation Reactions of Alcohols • Substitution Reactions of Haloalkanes • Reactions of Carbonyl Compounds • Formation of Esters • Reactions of Primary Amines • Designing Chemical Synthesis Processes • Limiting Reagents and the Theoretical Yield • Actual and Percentage Yield • Overall Reaction Efficiency • Green Chemistry Principles • Reaction Schemes • Monosaccharides • Condensation Reactions of Carbohydrates • Hydrolysis of Carbohydrates • Amino Acids • Amino Acid Reactions • Protein Structure and Sequencing • Formation & Hydrolysis of Amides • Metabolic Requirements • Structure, Properties and Functions of Lipids

Area of Study 2: How are organic compounds analysed and used?

Content Descriptor	**EP Lessons in *4.2.1. Laboratory analysis of organic compounds***
4.2.1.1. qualitative tests for the presence of carbon-carbon double bonds, hydroxyl and carboxyl functional groups **4.2.1.4.** volumetric analysis, including calculations of excess and limiting reactants using redox titrations (excluding back titrations)	• Dilutions • Standard Solutions • Buffer Solutions • Buffer Calculations • Introduction to Titrations • Performing a Titration • Titration Calculations • Titration Curves • Titration Curve Calculations: Before Equivalence • Titration Curve Calculations: To Equivalence and Beyond • Distinguishing Organic Compounds

Content Descriptor	**EP Lessons in *4.2.2. Instrumental analysis of organic compounds***
4.2.2.1. applications of mass spectrometry (excluding features of instrumentation and operation) and interpretation of qualitative and quantitative data, including identification of molecular ion peak, determination of molecular mass and identification of simple fragments **4.2.2.2.** identification of bond types by qualitative infrared spectroscopy (IR) data analysis using characteristic absorption bands **4.2.2.3.** structural determination of organic compounds by low resolution carbon-13 nuclear magnetic resonance (13C-NMR) spectral analysis, using chemical shift values to deduce the number and nature of different carbon environments **4.2.2.4.** structural determination of organic compounds by low and high resolution proton nuclear magnetic resonance (1H-NMR) spectral analysis, using chemical shift values, integration curves (where the height is proportional to the area underneath a peak) and peak splitting patterns (excluding coupling constants), and application of the n+1 rule (where n is the number of neighbouring protons) to deduce the number and nature of different proton environments **4.2.2.5.** the principles of chromatography, including high performance liquid chromatography (HPLC) and the use of retention times and the construction of a calibration curve to determine the concentration of an organic compound in a solution (excluding features of instrumentation and operation)	• Mass Spectrometry of Compounds • Infrared Spectroscopy • Principles of NMR Spectroscopy • Carbon-13 NMR • Proton NMR • Structural Determination • Chromatography Techniques

Content Descriptor	EP Lessons in *4.2.3. Medicinal chemistry*
4.2.3.2. identification of the structure and functional groups of organic molecules that are medicines **4.2.3.4.** enzymes as protein-based catalysts in living systems: primary, secondary, tertiary and quaternary structures and changes in enzyme function in terms of structure and bonding as a result of increased temperature (denaturation), decreased temperature (lowered activity), or changes in pH (formation of zwitterions and denaturation)	● Introducing Enzymes ● Enzyme structure ● Factors Affecting Enzymes ● Examples of Enzyme Reactions ● Digestive Enzymes ● Fuels and Pharmaceuticals