

1.1 Formulae and equations

Formulae and equations

Can you recall the formulae of common compounds and common ions?	☐	☐	☐
Can you write the formulae of ionic compounds from the charges on their ions?	☐	☐	☐
Can you work out the oxidation numbers of atoms in a compound or ion?	☐	☐	☐
Can you construct balanced chemical equations, including ionic equations, with correct state symbols?	☐	☐	☐

1.2 Basic ideas about atoms

Radioactivity

Can you describe the nature of radioactive decay and the resulting changes in atomic number and mass number, including alpha, beta, positron emission and electron capture?	☐	☐	☐
Can you describe the behaviour of α -, β - and γ -radiation in electric and magnetic fields?	☐	☐	☐
Can you compare the relative penetrating power of α -, β - and γ -radiation?	☐	☐	☐
Can you explain the meaning of half-life and use it in simple calculations of radioactive decay?	☐	☐	☐
Can you describe the adverse consequences for living cells of exposure to radiation?	☐	☐	☐
Can you describe uses of radioisotopes in health, medicine, radio-dating, industry and analysis?	☐	☐	☐

Ionisation energies and orbitals

Can you define standard molar first ionisation energy of gaseous atoms and explain its significance?	☐	☐	☐
Can you explain the variation in first ionisation energy from one element to another?	☐	☐	☐
Can you link successive ionisation energy values to the electronic structure of an atom?	☐	☐	☐
Can you draw the shapes of s- and p-orbitals?	☐	☐	☐
Can you state the order of s-, p- and d-orbital occupation and write electronic configurations for elements 1 to 36?	☐	☐	☐

Spectra

Can you explain the origin of emission and absorption spectra in terms of electron transitions between atomic energy levels?



Can you describe and explain the atomic emission spectrum of the hydrogen atom, including the Lyman and Balmer series?



Can you use $E = hf$ and $f = c/\lambda$ to relate energy, frequency and wavelength?



Can you state the order of increasing energy of infrared, visible and ultraviolet light?



Can you explain the significance of the convergence limit of the Lyman series and use its frequency to calculate the ionisation energy of the hydrogen atom?

**1.3 Chemical calculations****Relative masses and mass spectrometry**

Can you define relative atomic mass, relative isotopic mass, relative formula mass and relative molecular mass?



Can you describe the principles of the mass spectrometer?



Can you use mass spectrometer data to determine relative atomic mass and the relative abundance of isotopes?



Can you interpret simple mass spectra, such as that of chlorine gas, Cl_2 ?

**The mole and concentration**

Can you determine empirical and molecular formulae from given data?



Can you explain the relationship between the Avogadro constant, the mole and molar mass?



Can you convert between grams and moles?



Can you express concentration in g dm^{-3} and mol dm^{-3} , including solubility?

**Gases**

Can you use the molar volume of a gas and correct gas volumes for changes in temperature and pressure?



Can you use the ideal gas equation $pV = nRT$, with correct units?

**Reacting quantities and errors**

Can you use stoichiometry to calculate reacting quantities, including in acid-base titrations?



Can you calculate atom economy and explain its importance?



Can you calculate percentage yield?



Can you estimate the percentage error in a measurement?



Can you use percentage error to express numerical answers to an appropriate number of significant figures?



1.4 Bonding

Ionic and covalent bonding

Can you describe ionic bonding in terms of ion formation and attraction between positive and negative ions in an ionic crystal?



Can you describe covalent bonding, including coordinate (dative) bonding, in terms of shared electrons?



Can you explain a covalent bond as a balance between forces of attraction and repulsion within the molecule?



Can you explain why many bonds are intermediate in character between purely ionic and purely covalent?



Can you explain electronegativity and bond polarity?



Intermolecular forces

Can you explain why forces between molecules are much weaker than covalent and ionic bonds?



Can you describe permanent and temporary (induced) dipoles and their effects on physical properties such as boiling temperature and solubility?



Can you describe hydrogen bonding and explain its effect on physical properties such as boiling temperature and solubility?



Shapes of molecules

Can you use the VSEPR principle to predict the shapes of simple molecules and ions?



Can you state the bond angles in linear, trigonal planar, tetrahedral and octahedral molecules and ions?



Can you explain how lone pairs reduce bond angles, for example in NH_3 and H_2O ?



1.5 Solid structures

Solid structures

Can you describe and compare the crystal structures of sodium chloride and caesium chloride, including coordination numbers?



Can you describe the structures of diamond and graphite?



Can you describe the structures of iodine and ice?



Can you describe the 'electron sea' model for bonding in metals?



Can you relate physical properties (melting temperature, solubility, hardness, electrical conductivity) to structure and bonding in ionic compounds, giant molecular substances, simple molecular substances and metals?



1.6 The Periodic Table

Periodicity and redox

Can you explain that elements are arranged in order of atomic number in the Periodic Table?



Can you relate electronic structure to position in the s-, p- and d-blocks?



Can you describe oxidation and reduction in terms of electron transfer in reactions of s-, p- and d-block elements, compounds and ions?



Can you describe and explain trends in ionisation energy, melting temperature and electronegativity across periods and down groups?



Groups 1 and 2

Can you describe the reactions of Group 2 elements with oxygen and with water or steam?



Can you describe the reactions of aqueous Mg^{2+} , Ca^{2+} and Ba^{2+} with OH^- , CO_3^{2-} and SO_4^{2-} ions?



Can you recall the flame colours of compounds of Li, Na, K, Ca, Sr and Ba, and that Mg compounds give no colour?



Can you describe the trend in general reactivity of Group 1 and Group 2 metals?



Can you describe the trend in thermal stability of Group 2 carbonates and hydroxides?



Can you describe the trends in solubility of Group 2 hydroxides and sulfates?



Can you explain the basic character of the oxides and hydroxides of Group 1 and Group 2 metals?



Group 7

- | | |
|--|---|
| Can you describe and explain the trend in volatility of the halogens? | ☐ ☐ ☐ |
| Can you describe the reactions of the halogens with metals? | ☐ ☐ ☐ |
| Can you explain the trend in reactivity of the halogens in terms of relative oxidising power? | ☐ ☐ ☐ |
| Can you describe the reactions of aqueous Ag^+ with halide ions and the effect of adding dilute aqueous NH_3 ? | ☐ ☐ ☐ |
| Can you explain halogen displacement reactions in terms of redox? | ☐ ☐ ☐ |
| Can you describe the use of chlorine and fluoride ions in water treatment and discuss the related health and ethical issues? | ☐ ☐ ☐ |

Salts and gravimetric analysis

- | | |
|--|---|
| Can you describe how to prepare a soluble salt and obtain crystals by crystallisation? | ☐ ☐ ☐ |
| Can you describe how to prepare an insoluble salt by precipitation? | ☐ ☐ ☐ |
| Can you carry out and calculate results from simple gravimetric analysis? | ☐ ☐ ☐ |

1.7 Simple equilibria and acid-base reactions**Equilibria**

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|--|---|
| Can you explain reversible reactions and dynamic equilibrium? | ☐ ☐ ☐ |
| Can you use Le Chatelier's principle to deduce the effect of changes in temperature, concentration and pressure on an equilibrium? | ☐ ☐ ☐ |
| Can you write an expression for the equilibrium constant K_c and calculate it from given equilibrium concentrations? | ☐ ☐ ☐ |

Acids and bases

- | | |
|---|---|
| Can you define acids as donors of $\text{H}^+(\text{aq})$ and bases as acceptors of $\text{H}^+(\text{aq})$? | ☐ ☐ ☐ |
| Can you use $\text{pH} = -\log[\text{H}^+(\text{aq})]$ to convert between pH and $\text{H}^+(\text{aq})$ concentration? | ☐ ☐ ☐ |
| Can you carry out and calculate the results of acid-base titrations? | ☐ ☐ ☐ |
| Can you distinguish between strong and weak acids in terms of relative dissociation? | ☐ ☐ ☐ |

2.1 Thermochemistry

Thermochemistry

Can you define enthalpy change of reaction and enthalpy change of combustion?	☐ ☐ ☐
Can you define standard molar enthalpy change of formation, $\Delta_f H^\ominus$, and state standard conditions?	☐ ☐ ☐
Can you state Hess's law and use energy cycles to calculate enthalpy changes?	☐ ☐ ☐
Can you explain the concept of average bond enthalpies and use them in simple calculations?	☐ ☐ ☐
Can you calculate enthalpy changes from experimental data using $q = mc\Delta T$?	☐ ☐ ☐
Can you describe simple procedures to determine enthalpy changes, including indirect determination and enthalpy change of combustion?	☐ ☐ ☐

2.2 Rates of reaction

Rates of reaction

Can you use collision theory to explain the effects of changing conditions on reaction rate?	☐ ☐ ☐
Can you calculate rates from experimental data and establish the relationship between reactant concentrations and rate?	☐ ☐ ☐
Can you draw and interpret energy profiles and explain activation energy?	☐ ☐ ☐
Can you use the Boltzmann energy distribution curve to explain the rapid increase in rate with temperature?	☐ ☐ ☐
Can you state the characteristics of a catalyst?	☐ ☐ ☐
Can you explain how catalysts increase reaction rates by providing an alternative route of lower activation energy?	☐ ☐ ☐
Can you explain how colorimetry can be used to study some reaction rates?	☐ ☐ ☐
Can you describe measuring reaction rate by gas collection and precipitation methods and by an 'iodine clock' reaction?	☐ ☐ ☐

2.3 The wider impact of chemistry

The wider impact of chemistry

Can you discuss the social, economic and environmental impact of chemical synthesis?	☐ ☐ ☐
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Can you discuss the social, economic and environmental impact of the production of energy?



Can you explain the role of green chemistry in improving sustainability, for example atom economy, renewable feedstocks and reducing waste and energy use?



2.4 Organic compounds

Organic compounds

Can you represent simple organic compounds using shortened, displayed and skeletal formulae?



Can you name alkanes, alkenes, halogenoalkanes, alcohols and carboxylic acids using nomenclature rules?



Can you explain the effect of increasing chain length on melting/boiling temperature and solubility?



Can you explain the effect of functional groups on melting/boiling temperature and solubility?



Can you explain structural isomerism and draw structural isomers?



Can you describe species as electrophiles, nucleophiles or radicals?



Can you describe bond fission as homolytic or heterolytic?



2.5 Hydrocarbons

Alkanes

Can you write equations for the combustion of alkanes, including formation of carbon dioxide, carbon monoxide and acidic gases?



Can you discuss the benefits and drawbacks of using fossil fuels?



Can you describe C-C and C-H bonds in alkanes as σ -bonds?



Can you describe the mechanism of radical substitution, such as the photochlorination of alkanes, including initiation, propagation and termination?



Alkenes

Can you explain the difference in reactivity between alkanes and alkenes in terms of the C=C bond as a region of high electron density?



Can you describe the C=C bond in ethene and other alkenes as a π -bond and a σ -bond?



Can you explain E-Z isomerism in terms of restricted rotation about a carbon-carbon double bond?



Can you describe the mechanism of electrophilic addition, such as the addition of Br₂ to ethene?



Can you describe the bromine/bromine water and potassium manganate(VII) tests for alkenes?



Can you explain the orientation of the addition of HBr to propene in terms of the relative stabilities of the possible carbocations?



Can you state the conditions for the catalytic hydrogenation of ethene and explain the relevance of this reaction?



Can you describe addition polymerisation and draw repeat units of polymers of alkenes and substituted alkenes?



Can you discuss the economic importance of addition polymers?



2.6 Halogenoalkanes

Halogenoalkanes

Can you describe the elimination reaction of halogenoalkanes to form alkenes, for example HBr eliminated from 1-bromopropane to form propene?



Can you describe the mechanism of nucleophilic substitution, such as the reaction of OH⁻(aq) with primary halogenoalkanes?



Can you explain the effect of bond polarity and bond enthalpy on the ease of substitution of halogenoalkanes?



Can you describe the hydrolysis/Ag⁺(aq) test for halogenoalkanes?



Can you describe uses of halogenoalkanes as solvents, anaesthetics and refrigerants and why their use is tightly regulated?



Can you explain the adverse environmental effects of CFCs, using the relative bond strengths of C-H, C-F and C-Cl to explain their impact in the upper atmosphere?



Can you describe how to carry out a reflux, for example for the reaction of halogenoalkanes with hydroxide ions?



2.7 Alcohols and carboxylic acids

Alcohols

Can you describe the industrial preparation of ethanol from ethene?



Can you describe the preparation of ethanol and other alcohols by fermentation followed by distillation?



Can you discuss the issues relating to the use of biofuels?



Can you describe the dehydration reactions of alcohols?



Can you classify alcohols as primary, secondary or tertiary?



Can you describe the oxidation of primary alcohols to aldehydes and carboxylic acids and secondary alcohols to ketones?



Can you describe the dichromate(VI) test for primary and secondary alcohols?



Carboxylic acids

Can you describe the sodium hydrogencarbonate test for carboxylic acids?



Can you describe the reactions of carboxylic acids with bases, carbonates and hydrogencarbonates to form salts?



Can you describe the esterification reaction between a carboxylic acid and an alcohol?



Can you describe how to separate a product by distillation?



2.8

Instrumental analysis

Instrumental analysis

Can you use mass spectra, including molecular ion peaks and fragments, to identify chemical structure?



Can you use IR spectra to identify functional groups and chemical structure?



Can you use ^{13}C NMR spectra to identify chemical structure?



Can you use low resolution ^1H NMR spectra to identify chemical structure?



3.1 Redox and standard electrode potential**A-LEVEL ONLY****Redox and standard electrode potential**

Can you describe redox reactions in terms of electron transfer?	☐ ☐ ☐
Can you write half-equations and cell diagrams for redox systems?	☐ ☐ ☐
Can you define standard electrode potential and describe the role of the standard hydrogen electrode?	☐ ☐ ☐
Can you describe simple cells made from metal/metal-ion electrodes and from electrodes based on different oxidation states of the same element?	☐ ☐ ☐
Can you calculate cell EMF from standard electrode potentials?	☐ ☐ ☐
Can you use E_{cell} to predict the feasibility of a reaction?	☐ ☐ ☐
Can you explain the principles of the hydrogen fuel cell and discuss its benefits and drawbacks?	☐ ☐ ☐

3.2 Redox reactions**A-LEVEL ONLY****Redox reactions**

Can you write half-equations for the reduction of dichromate(VI) and manganate(VII) ions in acid?	☐ ☐ ☐
Can you write the half-equation for the oxidation of thiosulfate ions to tetrathionate ions?	☐ ☐ ☐
Can you combine half-equations to give stoichiometric redox equations?	☐ ☐ ☐
Can you describe the reaction of Cu^{2+} ions with iodide ions and the titration of the liberated iodine with thiosulfate?	☐ ☐ ☐
Can you carry out a redox titration and calculate results from it?	☐ ☐ ☐

3.3 Chemistry of the p-block**A-LEVEL ONLY****General features**

Can you describe the amphoteric behaviour of aluminium and lead compounds?	☐ ☐ ☐
Can you explain the increasing stability of the inert pair cation down Groups 3, 4 and 5?	☐ ☐ ☐
Can you explain why Group 3 compounds can be electron-deficient?	☐ ☐ ☐
Can you explain how elements in Groups 5 to 7 can expand their octet?	☐ ☐ ☐

Can you describe the structure of Al_2Cl_6 and donor-acceptor compounds such as NH_3BF_3 ?



Can you describe the structures of hexagonal and cubic boron nitride and relate them to their uses?



Group 4

Can you explain the change in relative stability of oxidation states II and IV down Group 4?



Can you describe the nature and acid-base properties of CO_2 and PbO ?



Can you describe the change in bonding down the Group 4 chlorides and their reactions with water?



Can you describe the reactions of $\text{Pb}_2^+(\text{aq})$ with $\text{NaOH}(\text{aq})$, Cl^- and I^- ions?



Group 7

Can you describe the reactions of chlorine with cold and with warm aqueous NaOH as disproportionation reactions?



Can you explain the bleaching and bactericidal action of chlorine and chlorate(I) ions?



Can you describe and explain the reactions of NaCl , NaBr and NaI with concentrated sulfuric acid?



3.4

Chemistry of the d-block transition metals

A-LEVEL ONLY

Oxidation states and complexes

Can you explain why d-block elements show variable oxidation states?



Can you recall the key oxidation states of Cr, Mn, Fe, Co and Cu and the colours of aqueous Cr^{3+} , CrO_4^{2-} , $\text{Cr}_2\text{O}_7^{2-}$, MnO_4^- , Co^{2+} , Fe^{2+} , Fe^{3+} and Cu^{2+} ?



Can you describe the bonding in tetrahedral and octahedral complexes in terms of coordinate bonds from ligands?



Can you explain the origin of colour in complexes in terms of splitting of d-orbitals?



Can you describe ligand exchange and changes in coordination number, for example $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ with concentrated HCl ?



Can you recall the colours and formulae of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$, $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$, $[\text{CuCl}_4]^{2-}$ and $[\text{CoCl}_4]^{2-}$?



Catalysis and reactions

Can you explain heterogeneous and homogeneous catalysis by transition metals and their compounds?



Can you describe the use of nickel in the hydrogenation of alkenes and iron in the Haber process?



Can you describe the use of vanadium(V) oxide in the contact process and manganese(IV) oxide in the decomposition of hydrogen peroxide?



Can you describe the reactions of Cr^{3+} , Fe^{2+} , Fe^{3+} and Cu^{2+} with OH^- , including with excess OH^- ?

**3.5 Chemical kinetics****A-LEVEL ONLY****Chemical kinetics**

Can you describe measuring reaction rate by sampling and quenching?



Can you deduce the order of a reaction from experimental results, including from graphs and initial rates?



Can you write and use the general rate equation, $\text{rate} = k[\text{A}]^m[\text{B}]^n$, including units of k ?



Can you explain the meaning of the rate-determining step?



Can you link a rate equation to a proposed reaction mechanism?



Can you use the Arrhenius equation to explain the effect of temperature and catalysts on k ?



Can you use the Arrhenius equation to calculate activation energy and the frequency factor?

**3.6 Enthalpy changes for solids and solutions****A-LEVEL ONLY****Enthalpy changes for solids and solutions**

Can you define enthalpy changes of atomisation, lattice formation and lattice breaking?



Can you define enthalpy changes of hydration and solution?



Can you explain solubility as a balance between lattice breaking and hydration enthalpies?



Can you construct Born-Haber cycles for simple ionic compounds and use them to calculate unknown enthalpy changes?



Can you use the sign of $\Delta_f H^\ominus$ as a qualitative indicator of a compound's stability?



3.7 Entropy and feasibility of reactions**A-LEVEL ONLY****Entropy and feasibility of reactions**

Can you explain entropy as a measure of the freedom of particles and that it increases in natural changes?	☐	☐	☐
Can you place gases, liquids and solids in order of entropy?	☐	☐	☐
Can you calculate entropy changes from absolute entropy values?	☐	☐	☐
Can you calculate the Gibbs free energy change using $\Delta G = \Delta H - T\Delta S$?	☐	☐	☐
Can you use a negative ΔG to predict whether a reaction is spontaneous (feasible)?	☐	☐	☐
Can you use entropy to explain why some endothermic processes are spontaneous?	☐	☐	☐

3.8 Equilibrium constants**A-LEVEL ONLY****Equilibrium constants**

Can you explain the effect of temperature on K_p and K_c for exothermic and endothermic reactions?	☐	☐	☐
Can you write expressions for K_p and K_c and calculate them from given data?	☐	☐	☐
Can you calculate equilibrium quantities from given data and equilibrium constants?	☐	☐	☐
Can you explain the significance of the magnitude of an equilibrium constant?	☐	☐	☐

3.9 Acid-base equilibria**A-LEVEL ONLY****Acid-base equilibria**

Can you use the Lowry-Brønsted theory to identify acids, bases and conjugate pairs?	☐	☐	☐
Can you distinguish between strong and weak acids and bases using K_a ?	☐	☐	☐
Can you explain the significance of the ionic product of water, K_w ?	☐	☐	☐
Can you calculate pH, K_a and pK_a for strong and weak acids?	☐	☐	☐
Can you calculate the pH of strong bases using K_w ?	☐	☐	☐
Can you sketch and explain titration curves for strong acid/strong base, strong acid/weak base, weak acid/strong base and weak acid/weak base?	☐	☐	☐
Can you explain buffer action and calculate the pH of buffer solutions?	☐	☐	☐
Can you explain the importance of buffers in living systems and industry?	☐	☐	☐

Can you explain the hydrolysis of salts formed from strong and weak acids and bases, and predict whether their solutions are acidic, neutral or alkaline?



Can you select suitable indicators for acid-base titrations?



4.1 Stereoisomerism**A-LEVEL ONLY****Stereoisomerism**

Can you distinguish stereoisomerism from structural isomerism and recognise E-Z and optical isomerism as types of stereoisomerism?



Can you explain the terms chiral centre, enantiomer, optical activity and racemic mixture?



Can you identify an asymmetric carbon atom and explain how it gives rise to optical isomerism?



Can you describe the effect of an enantiomer on plane-polarised light?

**4.2 Aromaticity****A-LEVEL ONLY****Aromaticity**

Can you describe the structure and bonding in benzene and other arenes, including delocalisation?



Can you explain the resistance of benzene to addition reactions?



Can you describe the mechanism of electrophilic substitution for the nitration of benzene?



Can you describe the halogenation of benzene and Friedel-Crafts alkylation as electrophilic substitution reactions?



Can you explain why the C-Cl bond in chlorobenzene is stronger than in chloroalkanes?

**4.3 Alcohols and phenols****A-LEVEL ONLY****Alcohols and phenols**

Can you describe the formation of primary and secondary alcohols from halogenoalkanes and from carbonyl compounds?



Can you describe the reactions of primary and secondary alcohols with hydrogen halides, ethanoyl chloride and carboxylic acids?



Can you explain the acidity of phenol?



Can you describe the reactions of phenol with bromine and with ethanoyl chloride?



Can you describe the $\text{FeCl}_3(\text{aq})$ test for phenols?



4.4

Aldehydes and ketones

A-LEVEL ONLY

Aldehydes and ketones

Can you describe the formation of aldehydes from primary alcohols and ketones from secondary alcohols by oxidation?



Can you distinguish aldehydes from ketones by ease of oxidation using Tollens' reagent and Fehling's reagent?



Can you describe the reduction of aldehydes and ketones using NaBH_4 ?



Can you describe the mechanism of nucleophilic addition, as in the addition of HCN to ethanal and propanone?



Can you describe the reaction with 2,4-DNPH as a test for the carbonyl group and its use in identifying specific aldehydes and ketones?



Can you describe the triiodomethane (iodoform) test for CH_3CO^- groups or their precursors?



4.5

Carboxylic acids and their derivatives

A-LEVEL ONLY

Acidity and preparation

Can you state and demonstrate the order of relative acidity of carboxylic acids, phenols, alcohols and water?



Can you describe the formation of carboxylic acids by oxidation of alcohols and aldehydes?



Can you describe the reduction of carboxylic acids using LiAlH_4 ?



Can you describe the formation of aromatic carboxylic acids by oxidation of methyl side-chains?



Can you describe the decarboxylation of carboxylic acids?



Derivatives

Can you describe the conversion of carboxylic acids to esters and acid chlorides, and the hydrolysis of these compounds?



Can you describe the conversion of carboxylic acids to amides and nitriles?



Can you describe the formation of nitriles from halogenoalkanes and of hydroxynitriles from aldehydes and ketones?



Can you describe the hydrolysis of nitriles and amides?



Can you describe the reduction of nitriles using LiAlH_4 ?



4.6 Amines**A-LEVEL ONLY****Amines**

Can you describe the formation of primary aliphatic amines from halogenoalkanes and from nitriles?	☐	☐	☐
Can you describe the formation of aromatic amines from nitrobenzenes?	☐	☐	☐
Can you explain the basicity of amines?	☐	☐	☐
Can you describe the ethanoylation of primary amines using ethanoyl chloride?	☐	☐	☐
Can you describe the reactions of primary aliphatic and aromatic amines with cold nitric(III) acid?	☐	☐	☐
Can you describe the coupling of benzenediazonium salts with phenols and aromatic amines?	☐	☐	☐
Can you explain the role of the $-N=N^-$ chromophore in azo dyes?	☐	☐	☐
Can you explain the origin of colour in terms of the wavelengths of visible light absorbed?	☐	☐	☐

4.7 Amino acids, peptides and proteins**A-LEVEL ONLY****Amino acids, peptides and proteins**

Can you state the general formula of α -amino acids and classify them?	☐	☐	☐
Can you explain the amphoteric and zwitterionic nature of amino acids and its effect on melting temperature and solubility?	☐	☐	☐
Can you show how α -amino acids combine to form dipeptides?	☐	☐	☐
Can you describe the formation of polypeptides and proteins?	☐	☐	☐
Can you describe the basic principles of the primary, secondary and tertiary structure of proteins?	☐	☐	☐
Can you explain the essential role of proteins in living systems, for example as enzymes?	☐	☐	☐

4.8 Organic synthesis and analysis**A-LEVEL ONLY****Synthesis and polymers**

Can you plan the synthesis of an organic compound through a sequence of reactions?	☐	☐	☐
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Can you explain the principles behind techniques for manipulation, separation and purification in organic chemistry, such as reflux, distillation, solvent extraction and recrystallisation?



Can you distinguish between condensation and addition polymerisation?



Can you describe the formation of polyesters and polyamides and draw their repeat units?



Analysis

Can you use melting temperature to judge purity?



Can you use high resolution ^1H NMR spectra, including splitting patterns, together with mass, IR and ^{13}C NMR data to determine the structure of organic molecules?



Can you use chromatographic data from TLC, paper chromatography, GC and HPLC to find the composition of mixtures?



5.1 Practical techniques**A-LEVEL ONLY****Practical techniques**

Can you use appropriate apparatus to measure mass, time, volume of liquids and gases, temperature and pH?



Can you use a water bath or electric heater for heating?



Can you set up electrochemical cells and measure voltages?



Can you carry out volumetric analysis using a pipette, burette and volumetric flask, including making a standard solution?



Can you use laboratory apparatus for organic techniques including reflux, distillation, filtration (including under reduced pressure), recrystallisation and use of a separating funnel?



Can you use melting temperature apparatus to assess purity?



Can you carry out paper and thin-layer chromatography?



Can you carry out qualitative tests for ions and organic functional groups?



Can you use a pH probe or colorimeter to collect data?



Can you work safely, carrying out risk assessments and handling chemicals and apparatus correctly?

**5.2 Analysis and evaluation****A-LEVEL ONLY****Analysis and evaluation**

Can you follow a detailed method to solve an experimental problem and record results with appropriate precision and units?



Can you process data, plot and interpret graphs, and calculate results to an appropriate number of significant figures?



Can you estimate percentage uncertainties and identify the main sources of error?



Can you evaluate methods and results and suggest improvements?



Can you plan experiments, including choosing apparatus and controlling variables?



Specified practical work

SP1 Can you carry out gravimetric analysis, for example by precipitation of a Group 2 metal carbonate or a metal chloride?	☐	☐	☐
SP2 Can you identify unknown solutions by qualitative analysis?	☐	☐	☐
SP3 Can you prepare a soluble salt by titration?	☐	☐	☐
SP4 Can you standardise an acid solution?	☐	☐	☐
SP5 Can you carry out a back titration, for example to determine the percentage of calcium carbonate in limestone?	☐	☐	☐
SP6 Can you carry out a double titration, for example to analyse a mixture of sodium hydroxide and sodium carbonate?	☐	☐	☐
SP7 Can you determine an enthalpy change of reaction indirectly, for example for magnesium oxide and carbon dioxide forming magnesium carbonate?	☐	☐	☐
SP8 Can you determine an enthalpy change of combustion?	☐	☐	☐
SP9 Can you investigate a rate of reaction by a gas collection method?	☐	☐	☐
SP10 Can you study an 'iodine clock' reaction?	☐	☐	☐
SP11 Can you carry out a nucleophilic substitution reaction, for example 1-bromobutane with aqueous sodium hydroxide?	☐	☐	☐
SP12 Can you prepare an ester and separate it by distillation?	☐	☐	☐
SP13 Can you construct electrochemical cells and measure E _{cell} ?	☐	☐	☐
SP14 Can you carry out a simple redox titration?	☐	☐	☐
SP15 Can you estimate the copper in copper(II) salts?	☐	☐	☐
SP16 Can you determine the order of a reaction, for example the oxidation of iodide ions by hydrogen peroxide in acid solution?	☐	☐	☐
SP17 Can you determine an equilibrium constant, for example for the reaction of ethanol and ethanoic acid?	☐	☐	☐
SP18 Can you carry out a titration using a pH probe, for example a weak acid against a weak base?	☐	☐	☐
SP19 Can you identify aldehydes and ketones by their reaction with 2,4-dinitrophenylhydrazine?	☐	☐	☐
SP20 Can you synthesise a liquid organic product, including separation using a separating funnel?	☐	☐	☐
SP21 Can you synthesise a solid organic product, including recrystallisation and determination of melting temperature?	☐	☐	☐

SP22 Can you carry out a two-step synthesis, including purification and determination of the melting temperature of the product?



SP23 Can you plan a sequence of tests to identify organic compounds from a given list?



SP24 Can you carry out paper chromatography separation, including two-way separation?

