

1.1

Formulae, equations and amounts of substance

Formulae and equations

Can you write ionic formulae by predicting ion charges from position in the Periodic Table and recalling common polyatomic ions (e.g. NO_3^- , SO_4^{2-} , CO_3^{2-} , OH^- , NH_4^+ , HCO_3^- , PO_4^{3-})?



Can you write and balance equations for unfamiliar reactions when given suitable information?



Can you write balanced full and ionic equations, with state symbols, for all the reactions you have studied?



Amounts of substance

Can you define Avogadro's constant, the mole and molar mass?



Can you use Avogadro's constant in calculations (e.g. number of particles, atoms or ions in a given mass)?



Can you calculate reacting masses from balanced equations, including when one reactant is in excess?



Can you explain the terms anhydrous, hydrated and water of crystallisation?



Can you calculate the number of moles of water of crystallisation from percentage composition or mass data (e.g. by heating to constant mass)?



1.2

Atomic structure

Particles, isotopes and relative masses

Can you describe the relative mass, relative charge and position in the atom of protons, neutrons and electrons?



Can you explain atomic number and mass number, and deduce the numbers of protons, neutrons and electrons in atoms and ions?



Can you define relative atomic mass and relative isotopic mass using the carbon-12 standard?



Can you define the term isotope?



Can you define relative molecular mass and relative formula mass, and calculate them from relative atomic masses?



Mass spectrometry

Can you calculate relative atomic mass from a mass spectrum showing isotopic abundances?



Can you use relative atomic mass to work out isotopic abundances (the reverse calculation)?



Can you predict the mass spectrum of a diatomic element such as chlorine (peaks at m/z 70, 72 and 74 in a 9:6:1 ratio)?

**Electronic structure**

Can you deduce the electronic configurations of atoms and ions up to krypton in terms of shells and subshells (s, p, d) using the building-up principle?



Can you explain that an orbital holds a maximum of two electrons with opposite spins?



Can you describe the shapes of s- and p-orbitals?



Can you classify elements as s-, p-, d- or f-block from their position in the Periodic Table?

**Ionisation energies**

Can you define first ionisation energy and successive ionisation energies, and write equations for them with state symbols?



Can you use successive ionisation energy data to deduce the group of an element and provide evidence for electron shells?



Can you explain the trend in first ionisation energy down a group?



Can you explain the general trend in first ionisation energy across a period, including the dips (e.g. between Mg and Al, and between P and S)?



Can you explain how a graph of first ionisation energies of elements up to krypton gives evidence for shells and subshells?

**1.3****Bonding****Ionic and covalent bonding**

Can you explain ionic bonding as electrostatic attraction between oppositely charged ions formed by electron transfer?



Can you draw dot-and-cross diagrams for ionic compounds?



Can you explain covalent bonding as the attraction between a shared pair of electrons and the nuclei of the bonded atoms?



Can you define the term lone pair?



Can you describe a co-ordinate (dative) bond, using the ammonium ion, NH_4^+ , as an example?



Can you draw dot-and-cross diagrams for molecules and ions containing single, double, triple and co-ordinate bonds?



Can you state the octet rule and describe its limitations (e.g. BF_3 , PCl_5 , SF_6)?



Electronegativity and metallic bonding

Can you define electronegativity and explain its trends down a group and across a period?



Can you explain bond polarity in terms of electronegativity difference and show it using partial charges (δ^+ and δ^-)?



Can you explain metallic bonding as the attraction between positive metal ions and a sea of delocalised electrons?



1.4-1.5

Intermolecular forces and structure

Intermolecular forces

Can you describe van der Waals' forces (induced dipole attractions) and explain how they arise?



Can you describe permanent dipole-dipole attractions?



Can you describe hydrogen bonding, including the conditions needed and how it is shown in diagrams (e.g. between water molecules)?



Can you explain how intermolecular forces affect the melting points, boiling points and solubility of covalent molecular substances?



Structure

Can you describe giant ionic, metallic, giant covalent (diamond and graphite) and molecular covalent structures?



Can you explain the physical properties of each structure type, including melting and boiling points, hardness and electrical conductivity?



Can you explain the trend in melting points across period 3 from sodium to argon in terms of structure and bonding?



1.6 Shapes of molecules and ions

1.6 Shapes of molecules and ions

Can you explain that the shape of a molecule or ion depends on the repulsion between electron pairs around the central atom?



Can you use VSEPR theory to predict the shapes and bond angles of molecules and ions with up to six electron pairs (e.g. linear, trigonal planar, tetrahedral, trigonal bipyramidal, octahedral)?



Can you explain why the bond angles in NH_3 (107°) and H_2O (104.5°) are smaller than the tetrahedral angle, using the relative repulsion of lone pairs and bonding pairs?



Can you distinguish between a polar bond and a polar molecule, and predict whether a molecule is polar from its shape?



1.7 Redox

1.7 Redox

Can you calculate oxidation states of elements in compounds and ions, including in peroxides and metal hydrides?



Can you define redox and explain oxidation and reduction in terms of electron transfer and changes in oxidation state?



Can you explain that oxidising agents gain electrons and reducing agents lose electrons?



Can you define disproportionation and identify it in a reaction using oxidation numbers?



Can you write half-equations and combine them to give a balanced redox equation?



Can you use Roman numerals to name species containing an element in different oxidation states (e.g. iron(II), chlorate(I), chlorate(V))?



1.8 Halogens

Physical properties

Can you recall the colours and states of the halogens and explain the trends in melting and boiling points down the group?



Can you compare the solubility and colours of the halogens in water and in non-aqueous (organic) solvents?



Reactions

Can you describe the reactions of chlorine with cold dilute and hot concentrated sodium hydroxide, and explain them as disproportionation?



Can you recall the reaction of chlorine with water?



Can you describe the trend in oxidising ability of the halogens using displacement reactions with halide ions?



Can you explain the reactions of solid halides with concentrated sulfuric acid and concentrated phosphoric acid, in terms of the reducing ability of the halide ions?



Can you compare the advantages and disadvantages of adding chlorine or ozone to drinking water?

**1.9 Acid-base titrations****Acids, bases and titration technique**

Can you explain the terms strong and weak acid and strong and weak base in terms of dissociation into ions?



Can you describe the technique for titrations of strong acid/strong base, strong acid/weak base and weak acid/strong base?



Can you select a suitable indicator for each type of titration and recall the end-point colour changes of phenolphthalein and methyl orange?

**Data handling and calculations**

Can you identify sources of measurement uncertainty and calculate the uncertainty in a titre from two burette readings?



Can you select concordant titration results, excluding outliers, to calculate a mean titre?



Can you carry out titration calculations to find unknown concentrations and volumes?



Can you explain molarity and use concentration units of mol dm^{-3} and g dm^{-3} ?



Can you describe how to prepare a standard solution of a required concentration using a volumetric flask?

**1.10 Qualitative tests****1.10 Qualitative tests**

Can you describe chemical tests for the gases H_2 , O_2 , Cl_2 , CO_2 , HCl and NH_3 ?



Can you carry out a flame test using a nichrome wire?



Can you recall the flame test colours for Li^+ , Na^+ , K^+ , Ca^{2+} , Ba^{2+} and Cu^{2+} ?



Can you test for the ammonium ion by warming with sodium hydroxide solution?



Can you test for sulfate ions using barium chloride solution?



Can you test for halide ions using silver nitrate solution, and use ammonia solution to confirm which halide is present?



Can you test for carbonate ions using dilute acid and limewater?



Can you use starch to identify iodine?



2.1 Formulae and amounts of substance

2.1 Formulae and amounts of substance

Can you define empirical formula and molecular formula and explain how they are related?



Can you calculate empirical and molecular formulae from mass or percentage composition data?



Can you define molar gas volume and use it to calculate volumes of gases in reactions?



Can you define percentage yield and calculate it from equations and experimental data?



Can you use a percentage yield to calculate the mass of reagent needed to make a required amount of product?



Can you define atom economy and calculate it from a balanced equation?



2.2 Nomenclature and isomerism in organic compounds

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Can you define structural isomerism, geometric isomerism, homologous series and functional group?



Can you apply IUPAC rules to name organic compounds with up to six carbon atoms and one or more functional groups?



Can you draw and name structural isomers of non-cyclic aliphatic compounds with up to six carbon atoms?



Can you draw structural and skeletal formulae of organic compounds?



Can you explain that geometric isomerism arises from restricted rotation about a C=C double bond, giving E and Z isomers?



Can you draw and identify the structural formulae of E and Z isomers?



2.3 Alkanes

Physical properties and combustion

Can you recall that alkanes are saturated hydrocarbons?



Can you explain, using van der Waals' forces, how the boiling points of alkanes change with chain length?



Can you explain, using van der Waals' forces, why branched structural isomers have lower boiling points than straight-chain isomers?



Can you describe complete and incomplete combustion of alkanes and relate flame appearance (sootiness) to carbon content?



Can you recall the pollutants formed when alkanes burn: carbon monoxide, carbon (soot), oxides of nitrogen, oxides of sulfur and unburned hydrocarbons?



Can you recall that combustion has raised atmospheric CO₂ from about 0.03% to 0.04% and that this is linked to global warming?



Can you explain how a catalytic converter reduces the environmental impact of alkane fuels?



Radical substitution

Can you describe the substitution reactions of alkanes with chlorine and bromine in UV light?



Can you define radical, homolytic fission and heterolytic fission?



Can you outline the radical substitution mechanism for photochemical halogenation of an alkane, showing initiation, propagation and termination steps?



2.4 Alkenes

Structure and reactivity

Can you define unsaturated hydrocarbon and explain why alkenes are unsaturated?



Can you recall the bromine water test for an alkene (orange to colourless)?



Can you use sigma (σ) and pi (π) bonding to explain the relative strength and length of a C=C bond compared with a C-C bond?



Can you explain, using the high electron density of the C=C bond, why alkenes are more reactive than alkanes?



Addition reactions

Can you describe the catalytic hydrogenation of alkenes using a finely divided nickel catalyst?



Can you describe the addition reactions of alkenes with chlorine, bromine, hydrogen chloride and hydrogen bromide?



Can you define electrophile and heterolytic fission?



Can you outline, using curly arrows, the electrophilic addition mechanism for the reaction of alkenes with halogens and hydrogen halides?



Can you explain the formation of major and minor products when HBr adds to an unsymmetrical alkene, using carbocation stability?



Can you describe addition polymerisation of alkenes such as ethene and propene, and draw the repeating unit?



2.5 Halogenoalkanes

Properties and preparation

Can you explain how the boiling points of halogenoalkanes vary with the halogen atom?



Can you explain the differences in boiling point between structural isomers of halogenoalkanes?



Can you classify halogenoalkanes as primary, secondary or tertiary?



Can you describe the laboratory preparation of a liquid organic compound such as a halogenoalkane from an alcohol (reflux, separation, washing, drying and distillation)?



Reactions

Can you describe the reactions of halogenoalkanes with aqueous alkali, ammonia and potassium cyanide?



Can you define nucleophile and outline the nucleophilic substitution mechanism for primary and tertiary halogenoalkanes with aqueous alkali?



Can you explain, using bond enthalpies, the relative rates of hydrolysis of primary chloro-, bromo- and iodoalkanes?



Can you describe the elimination of hydrogen halides from symmetrical and unsymmetrical halogenoalkanes using ethanolic potassium hydroxide?



Can you recall that CFCs contribute to depletion of the ozone layer, letting more harmful UV radiation reach the Earth?



2.6 Alcohols

2.6 Alcohols

Can you explain the effect of hydrogen bonding on the boiling points and solubility in water of alcohols?



Can you classify alcohols as primary, secondary or tertiary?



Can you recall the preparation of alcohols from halogenoalkanes?



Can you describe the complete and incomplete combustion of alcohols and their use as alternative fuels?



Can you describe the reactions of alcohols with sodium, hydrogen bromide and phosphorus pentachloride?



Can you describe the oxidation of primary alcohols to aldehydes and carboxylic acids using acidified potassium dichromate(VI), including the conditions (distillation versus reflux)?



Can you describe the oxidation of secondary alcohols to ketones and explain why tertiary alcohols are resistant to oxidation?



2.7 Infrared spectroscopy

2.7 Infrared spectroscopy

Can you explain that infrared absorption is caused by bond vibrations in molecules?



Can you explain that groups of atoms absorb infrared radiation at characteristic wavenumbers?



Can you use infrared wavenumber data to deduce the functional groups present in an organic compound (e.g. O-H, C=O, C-H)?



2.8 Energetics

Enthalpy changes

Can you define exothermic and endothermic and recognise that reactions are usually accompanied by heat changes?



Can you recall the standard conditions of 100 kPa and 298 K?



Can you define standard enthalpy change, $\Delta H^\ominus$?



Can you construct a simple enthalpy level diagram?



Can you define standard enthalpy of combustion, standard enthalpy of formation and standard enthalpy of neutralisation ($\Delta_c H^\ominus$, $\Delta_f H^\ominus$, $\Delta_n H^\ominus$)?



Can you recall experimental methods for determining enthalpy changes of combustion and neutralisation?



Can you calculate enthalpy changes from experimental data using $q = mc\Delta T$?



Hess's Law and bond enthalpies

Can you explain the principle of conservation of energy and define Hess's Law?



Can you construct enthalpy cycles using Hess's Law?



Can you calculate enthalpy changes indirectly using Hess's Law (e.g. from enthalpies of formation or combustion)?



Can you define average bond enthalpy and use it to calculate the enthalpy change of a reaction?



Can you calculate an average bond enthalpy from a known reaction enthalpy change?



Can you explain why enthalpy changes calculated from average bond enthalpies differ from those found using Hess's Law?



2.9 Kinetics

2.9 Kinetics

Can you recall how concentration, pressure, temperature and catalysts affect the rate of a reaction?



Can you use collision theory and activation energy to explain qualitatively the effects of these factors on rate?



Can you draw and explain Maxwell-Boltzmann distribution curves at different temperatures?



Can you use a Maxwell-Boltzmann distribution to explain the effect of a catalyst, relating activation energy to the proportion of molecules with enough energy to react?



2.10 Equilibrium

2.10 Equilibrium

Can you explain that many reactions are reversible and define dynamic equilibrium, homogeneous and heterogeneous?



Can you deduce the qualitative effects of changes in temperature, pressure and concentration, and of a catalyst, on the position of a homogeneous equilibrium in a closed system?



Can you deduce the expression for K_c , and its units, for a homogeneous equilibrium?



Can you relate the size of K_c to the position of equilibrium and the extent of reaction?



Can you describe and explain the industrial conditions used in the Haber process for ammonia?



Can you describe and explain the industrial conditions used in the Contact process for sulfuric acid?



Can you explain the compromise between equilibrium yield and rate of reaction in choosing industrial conditions?



Elements and reactions

Can you explain why the Group II elements are s-block elements?



Can you recall and explain the trends down Group II in electronic configuration, atomic radius and first ionisation energy?



Can you describe the reactions of Group II elements with oxygen, water and dilute acids?



Can you describe the basic nature of Group II oxides and their reactions with water and dilute acids?



Can you recall the use of magnesium oxide in indigestion remedies and calcium carbonate in toothpaste?

**Compounds**

Can you state and explain the trend in thermal stability of Group II carbonates and hydroxides in terms of the charge and size of the cation?



Can you recall how calcium carbonate is used to make quicklime (CaO) and slaked lime (Ca(OH)₂), and their uses in cement and concrete?



Can you recall the trends in solubility of Group II sulfates and hydroxides?



Can you explain how solubility curves are plotted from experimental data?



4.1 Lattice enthalpy**A-LEVEL ONLY****4.1 Lattice enthalpy**

Can you define lattice enthalpy and explain its meaning?



Can you construct Born-Haber cycles for Group I and II halides and oxides and use them in calculations?



Can you define and explain the enthalpy changes of solution and hydration when ionic compounds dissolve in water?



Can you carry out calculations using lattice enthalpy, enthalpy of hydration and enthalpy of solution?

**4.2 Enthalpy, entropy and free energy****A-LEVEL ONLY****4.2 Enthalpy, entropy and free energy**

Can you explain why enthalpy change alone cannot predict feasibility, using the endothermic reaction of ammonium carbonate with ethanoic acid as an example?



Can you explain that feasibility depends on the balance between entropy and enthalpy changes?



Can you explain that entropy is a measure of disorder?



Can you calculate the standard entropy change of a reaction from standard entropy values?

Can you use $\Delta G = \Delta H - T\Delta S$ to calculate standard free energy changes?Can you explain that a process is feasible when ΔG is negative?Can you explain that when ΔH and ΔS have the same sign feasibility depends on temperature, and calculate the temperature at which a reaction becomes (or stops being) feasible?**4.3 Rates of reaction****A-LEVEL ONLY****Rate equations**Can you use rate equations of the form $\text{rate} = k[A]^x[B]^y$, where x and y are 0, 1 or 2?

Can you explain the terms rate of reaction, order of reaction and rate constant?



Can you deduce rate equations from experimental (initial rates) data?



Can you deduce rate and order with respect to a reactant from concentration-time and rate-concentration graphs?



Mechanisms and methods

Can you link rate equations to mechanisms, e.g. SN_1 and SN_2 for the alkaline hydrolysis of tertiary and primary halogenoalkanes?



Can you define and explain the rate-determining step?



Can you suggest suitable methods for following reaction rates, such as iodine titrations and colorimetry?



Can you explain qualitatively how temperature and activation energy affect the rate constant?

**4.4 Equilibrium****A-LEVEL ONLY****4.4 Equilibrium**

Can you calculate equilibrium concentrations (amounts at equilibrium) from initial amounts and suitable data?



Can you calculate values of K_c , with units, for homogeneous equilibria?



Can you use a value of K_c to calculate an unknown equilibrium concentration?

**4.5 Acid-base equilibria****A-LEVEL ONLY****Acids, bases and pH**

Can you use Brønsted-Lowry theory to describe acids and bases as proton donors and acceptors, and identify conjugate acid-base pairs?



Can you explain the terms K_w , K_a , pH, pK_w and pK_a and state the units of K_w and K_a ?



Can you calculate the pH of strong acids and strong bases?



Can you calculate the pH of a weak acid from its concentration and K_a (and K_a from pH)?

**Buffers, titration curves and salts**

Can you define a buffer solution and explain qualitatively how it resists changes in pH?



Can you calculate the pH of a buffer made from a weak monobasic acid and sodium hydroxide?



Can you describe how a titration curve is determined experimentally using a pH meter?



Can you use titration curves for different acid-base combinations to justify the choice of indicator?



Can you predict whether a salt solution is acidic, alkaline or neutral from the relative strengths of its parent acid and base?



4.6 Isomerism

A-LEVEL ONLY

4.6 Isomerism

Can you explain how structural isomers can exist between different families of compounds (e.g. aldehydes and ketones, carboxylic acids and esters)?



Can you recognise that a chiral (asymmetric) centre gives rise to optical isomers that are non-superimposable mirror images?



Can you draw 3D representations of a pair of optical isomers?



Can you state that optical isomers rotate plane-polarised light in opposite directions?



Can you define optically active and explain why a racemic mixture is optically inactive?



Can you explain how drug action depends on stereochemistry because receptor sites can be stereospecific?



4.7 Aldehydes and ketones

A-LEVEL ONLY

Structure, properties and preparation

Can you recall the molecular and structural formulae of aldehydes and ketones with up to six carbon atoms in the main chain, including branched structures?



Can you explain the boiling points and solubility of aldehydes and ketones in terms of intermolecular forces?



Can you recall that aldehydes and ketones are made by oxidising primary and secondary alcohols respectively?



Reactions and tests

Can you recall the reaction of aldehydes and ketones with hydrogen cyanide?



Can you describe the nucleophilic addition mechanism for the reaction of hydrogen cyanide with propanone?



Can you explain why a racemic mixture can form when hydrogen cyanide reacts with aldehydes and unsymmetrical ketones?



Can you recall the reaction with 2,4-dinitrophenylhydrazine and how the derivatives are used to identify aldehydes and ketones?



Can you distinguish between aldehydes and ketones using acidified potassium dichromate(VI), Fehling's solution and Tollens' reagent, giving observations?



Can you recall the reduction of aldehydes and ketones to alcohols using lithium tetrahydridoaluminate(III) (lithal)?



4.8 Carboxylic acids

A-LEVEL ONLY

4.8 Carboxylic acids

Can you recall the molecular and structural formulae of carboxylic acids with up to six carbon atoms in the main chain, including branched structures?



Can you explain the boiling points and solubility of carboxylic acids in terms of intermolecular forces?



Can you recall, with practical details, the preparation of carboxylic acids from primary alcohols and aldehydes?



Can you recall that carboxylic acids or their salts are formed by acid- or base-catalysed hydrolysis of esters and nitriles?



Can you recall the formation of salts of carboxylic acids with sodium carbonate, sodium hydroxide and ammonia?



Can you recall the reactions of carboxylic acids with alcohols, phosphorus pentachloride and lithal?



4.9 Derivatives of carboxylic acids

A-LEVEL ONLY

Esters and acyl chlorides

Can you recall that esters and acyl chlorides are derivatives of carboxylic acids?



Can you recall the molecular and structural formulae of monoesters and acyl chlorides?



Can you explain the boiling points and solubility of monoesters in terms of intermolecular forces?



Can you recall that esters are made from alcohols using carboxylic acids or acyl chlorides?



Can you recall the laboratory preparation of a liquid ester from a carboxylic acid and an alcohol?



Can you recall the reactions of acyl chlorides with water and with alcohols?



Fats, oils and biodiesel

Can you recall that fats and oils are esters of propane-1,2,3-triol (glycerol) and fatty acids?



Can you recall transesterification reactions and their use in making biodiesel and margarines?



Can you recall that margarines and spreads are made by hardening oils through catalytic hydrogenation using finely divided nickel?

**4.10****Aromatic chemistry****A-LEVEL ONLY****4.10 Aromatic chemistry**

Can you explain the structure of benzene in terms of delocalised π electrons?



Can you explain the different reactivity of benzene and alkenes in terms of the stability of their π electron systems (e.g. benzene's resistance to addition of bromine)?



Can you explain the electrophilic substitution mechanisms for monobromination and mononitration of benzene, including how the electrophile is formed?



Can you explain the electrophilic substitution mechanisms for monoalkylation and monoacylation (Friedel-Crafts) of benzene, including how the electrophile is formed?



Can you name the electrophiles in the bromination (Br^+) and nitration (NO_2^+ , nitronium ion) of benzene?



Can you describe the preparation of methyl 3-nitrobenzoate from methyl benzoate as an example of nitration of a benzene ring?



5.1-5.2

Mass spectrometry and NMR

A-LEVEL ONLY

Mass spectrometry

Can you identify the base peak, molecular ion peak, M+1 peak and fragment ions in a mass spectrum?



Can you suggest formulae for fragment ions in a given mass spectrum?



Can you use high-resolution mass spectrometry to distinguish between molecules with the same relative molecular mass?



NMR spectroscopy

Can you explain the difference between low-resolution and high-resolution NMR spectra?



Can you explain why TMS (tetramethylsilane) is used as a standard?



Can you recognise chemically equivalent hydrogen atoms in a molecule?



Can you explain that chemical shift depends on the chemical environment of the hydrogen atoms?



Can you use integration curves to find the relative numbers of hydrogen atoms in each environment?



Can you apply the n+1 rule to spin-spin splitting, giving doublets, triplets and quartets?



Can you deduce the structure of a molecule from an NMR spectrum with simple splitting patterns?



5.3-5.4

Volumetric analysis and chromatography

A-LEVEL ONLY

Volumetric analysis

Can you describe the titration of iodine with sodium thiosulfate using starch indicator?



Can you estimate oxidising agents such as hydrogen peroxide and iodate(V) ions by reacting them with excess acidified potassium iodide and titrating the iodine released?



Can you describe titrations of acidified potassium manganate(VII) with iron(II) and other reducing agents, including the self-indicating end point?



Can you deduce overall titration equations from the half-equations of the oxidant and reductant?



Can you explain back titration and use it, for example, to determine the purity of a Group II metal oxide or carbonate?



Chromatography

Can you describe and explain how one-way and two-way paper chromatography and thin-layer chromatography (TLC) are carried out?



Can you describe and explain how gas-liquid chromatography (GLC) is carried out, qualitatively and quantitatively?



Can you interpret GLC data to find the percentage composition of a mixture?



Can you interpret one-way and two-way paper and TLC chromatograms, including calculating R_f values?

**5.5 Transition metals****A-LEVEL ONLY****Properties and complexes**

Can you recall that transition metals have an incomplete d-subshell in the atom or ion, variable oxidation states, catalytic activity and form coloured complexes?



Can you deduce the electronic configurations of transition metal atoms and ions (including Cr and Cu) and explain their stabilities in terms of subshell filling?



Can you describe a complex as a central metal atom or ion surrounded by ligands, which are anions or molecules with lone pairs?



Can you explain that a ligand donates a lone pair of electrons to the metal to form a co-ordinate bond?



Can you explain and deduce co-ordination numbers in complexes?



Can you deduce the oxidation number of a transition metal in a complex and use oxidation numbers to explain redox and disproportionation reactions?



Can you distinguish monodentate (e.g. Cl^- , H_2O , NH_3), bidentate (e.g. en, $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$) and polydentate (e.g. edta) ligands?

**Ligand replacement**

Can you explain the relative strengths of ligands in terms of the availability of their lone pairs?



Can you describe ligand replacement in the hexaaquacopper(II) ion with concentrated hydrochloric acid and with ammonia solution, giving the colours and shapes of the complexes formed?



Can you explain ligand replacement (the chelate effect) in terms of a positive entropy change, e.g. a bidentate ligand replacing two monodentate ligands?



Colours, tests and vanadium

Can you recall the colours of aqueous ions and complexes of Cr^{3+} , Cr(VI) , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^{2+} , V^{2+} , V^{3+} , V(IV) and V(V) ?



Can you use the precipitates formed by Cr^{3+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} and Cu^{2+} with NaOH(aq) and $\text{NH}_3(\text{aq})$ as qualitative tests, including where the precipitate dissolves in excess?



Can you recall the reduction of V(V) (from acidified ammonium metavanadate) by zinc to V(IV) , V^{3+} and V^{2+} , with the colour changes?



Can you use emf values to choose reagents that interconvert vanadium oxidation states, and combine half-equations to write overall equations?

**5.6 Electrode potentials****A-LEVEL ONLY****Electrode potentials**

Can you define standard electrode potential and describe the construction and significance of the standard hydrogen electrode?



Can you explain why standard conditions are needed when measuring electrode potentials?



Can you use standard electrode potentials to calculate the emf of a cell and predict the feasibility and direction of a reaction?



Can you explain the limitations of predictions from electrode potentials, relating to concentration and kinetics?



Can you use conventional cell notation?

**Cells**

Can you classify cells as non-rechargeable, rechargeable or fuel cells and give examples of each?



Can you describe the electrode reactions in a lithium cell?



Can you explain that a fuel cell generates a voltage from the reaction of a fuel with oxygen?



Can you recall the electrode reactions in an alkaline hydrogen-oxygen fuel cell?



Can you recall the environmental issues associated with the use and disposal of cells?



5.7-5.8

Amines and amides

A-LEVEL ONLY

Amines

Can you recall the formulae of primary, secondary and tertiary amines with up to six carbon atoms?



Can you explain the effect of hydrogen bonding on the boiling points and solubility in water of amines?



Can you recall the formation of primary aliphatic amines by reduction of nitriles with lithal and by reaction of ammonia with halogenoalkanes?



Can you explain the preparation of phenylamine by reducing nitrobenzene with tin and concentrated HCl, then adding alkali to liberate the free amine from the phenylammonium salt?



Can you recall that amines react with mineral acids to form salts and that alkali liberates the amine from its salt?



Can you explain the relative basic strengths of ammonia, primary, secondary and tertiary aliphatic amines and phenylamine in terms of lone pair availability?



Can you recall the reaction of amines with ethanoyl chloride and use it to identify unknown amines?



Can you explain the formation of benzenediazonium chloride from phenylamine and recall the coupling of diazonium ions with phenol and phenylamine?



Can you explain the colours of dyestuffs and indicators in terms of the extent of electron delocalisation?



Amides

Can you recall the preparation of amides from carboxylic acids and ammonia, and from amines and acyl chlorides?



Can you recall the hydrolysis of amides using acids and alkalis?



Can you recall the dehydration of amides to nitriles using phosphorus pentoxide?



Can you explain why amides are much weaker bases than amines, in terms of delocalisation of the nitrogen lone pair?



5.9

Amino acids

A-LEVEL ONLY

Amino acids

Can you recall the formulae of glycine and alanine?



Can you explain the optical activity of amino acids (except glycine)?



Can you explain the formation of zwitterions (dipolar ions) by amino acids?

☐ ☐ ☐

Can you explain the solubility of amino acids in water and their relatively high melting points?

☐ ☐ ☐

Can you recall the reactions of amino acids with sodium carbonate, copper(II) sulfate and nitrous acid?

☐ ☐ ☐

Proteins and enzymes

Can you recall the formation of peptide links and the primary, secondary and tertiary structures of proteins?

☐ ☐ ☐

Can you define enzymes as biological catalysts and use the induced fit model to explain enzyme action?

☐ ☐ ☐

Can you recall the use of enzymes in washing powders and the economic advantage of them working at lower temperatures?

☐ ☐ ☐

Can you explain that enzymes are proteins that provide an alternative pathway with a lower activation energy?

☐ ☐ ☐

Can you explain how pH and temperature affect enzyme activity?

☐ ☐ ☐

5.10 Polymer chemistry

A-LEVEL ONLY

5.10 Polymer chemistry

Can you explain that condensation polymers form from monomers containing COOH, OH and NH₂ groups?

☐ ☐ ☐

Can you draw the structure of a condensation polymer from its monomers, and deduce the monomers from a polymer structure?

☐ ☐ ☐

Can you explain the formation, structure and uses of polyethylene terephthalate (PET) as a polyester?

☐ ☐ ☐

Can you explain the formation, structure and uses of nylon as a polyamide?

☐ ☐ ☐

Can you recall that polyesters and polyamides can be hydrolysed and are therefore biodegradable?

☐ ☐ ☐

5.11 Chemistry in medicine

A-LEVEL ONLY

Remedies and treatments

Can you recall the use of hydroxides and carbonates in indigestion remedies to neutralise excess stomach acid?

☐ ☐ ☐

Can you use a back titration to determine the percentage of active ingredient in an indigestion remedy?



Can you recall how excessively high or low skin pH is treated, and explain how corrosive chemicals are used to remove warts?



Can you explain the use of silver nitrate in treating eye diseases?



Can you explain how anticancer drugs such as cisplatin prevent DNA replication in cancer cells, and how changing the structure of cisplatin affects its efficiency?



Aspirin and drug analysis

Can you use volumetric analysis to determine the concentration of aspirin in a solution?



Can you recall the synthesis of aspirin from salicylic acid using ethanoic anhydride, and explain why aspirin is often used as its sodium salt?



Can you use TLC and GLC-MS to identify drugs and assess their purity?



Blood chemistry

Can you explain the role of iron(II) in haemoglobin in transporting oxygen, and why carbon monoxide is poisonous?



Can you explain how edta sequesters calcium ions and so prevents blood clotting?



Practical activities

AS3-1 Can you find the formula of a hydrated compound by weighing and heating to constant mass?	☐	☐	☐
AS3-2 Can you test for molecular polarity by deflecting a stream of liquid from a burette with a charged rod?	☐	☐	☐
AS3-3 Can you test the electrical conductivity of solids, liquids and aqueous solutions?	☐	☐	☐
AS3-4 Can you investigate the solubility of chlorine and iodine in aqueous and non-aqueous solvents?	☐	☐	☐
AS3-5 Can you use displacement reactions to put the halogens in order of reactivity?	☐	☐	☐
AS3-6 Can you react solid halides with concentrated sulfuric and phosphoric acids and test the products (excluding hydrogen sulfide)?	☐	☐	☐
AS3-7 Can you carry out titrations to find the concentration of an acid or base, the degree of hydration of a metal carbonate and the ethanoic acid content of vinegar?	☐	☐	☐
AS3-8 Can you prepare solutions of known concentration?	☐	☐	☐
AS3-9 Can you use qualitative tests to identify unknown substances?	☐	☐	☐
AS3-10 Can you test for unsaturation using bromine water?	☐	☐	☐
AS3-11 Can you prepare a halogenoalkane by refluxing, separating, washing, drying and distilling?	☐	☐	☐
AS3-12 Can you prepare an alcohol from a halogenoalkane using alkali?	☐	☐	☐
AS3-13 Can you investigate the relative rates of hydrolysis of halogenoalkanes?	☐	☐	☐
AS3-14 Can you eliminate a hydrogen halide from a halogenoalkane using ethanolic potassium hydroxide?	☐	☐	☐
AS3-15 Can you test alcohols with sodium, hydrogen bromide and phosphorus pentachloride?	☐	☐	☐
AS3-16 Can you prepare aldehydes, carboxylic acids and ketones from alcohols using acidified potassium dichromate(VI)?	☐	☐	☐
AS3-17 Can you determine enthalpy changes of combustion and neutralisation experimentally?	☐	☐	☐
AS3-18 Can you react Group II and other metals with oxygen, water and dilute acids, measuring masses of solids and volumes of gases?	☐	☐	☐
A23-1 Can you determine reaction rates using different methods of measuring reactant or product concentration?	☐	☐	☐
A23-2 Can you make buffer solutions from calculated amounts of acid and salt and measure their pH with indicator paper and a pH meter?	☐	☐	☐

A23-3 Can you determine the shape of a titration curve by measuring pH?	☐	☐	☐
A23-4 Can you measure the pH of salt solutions to show the relative strengths of their parent acids and bases?	☐	☐	☐
A23-5 Can you use Fehling's solution and Tollens' reagent to distinguish aldehydes from ketones?	☐	☐	☐
A23-6 Can you prepare a carboxylic acid from an alcohol?	☐	☐	☐
A23-7 Can you react a carboxylic acid with sodium carbonate, sodium hydroxide and aqueous ammonia, measuring pH changes?	☐	☐	☐
A23-8 Can you prepare a liquid ester from a carboxylic acid and an alcohol?	☐	☐	☐
A23-9 Can you titrate iodine with sodium thiosulfate using starch, and estimate oxidising agents using excess acidified potassium iodide?	☐	☐	☐
A23-10 Can you titrate acidified potassium manganate(VII) with reducing agents?	☐	☐	☐
A23-11 Can you determine the purity of a Group II metal oxide or carbonate by back titration?	☐	☐	☐
A23-12 Can you carry out paper and thin-layer chromatography, measure R _f values and interpret chromatograms?	☐	☐	☐
A23-13 Can you demonstrate ligand replacement using ethylenediamine, phenylamine and aqueous ammonia?	☐	☐	☐
A23-14 Can you show relative ligand strengths using hydrated copper(II) ions and hydrochloric acid?	☐	☐	☐
A23-15 Can you carry out qualitative tests for transition metal ions using sodium hydroxide and aqueous ammonia?	☐	☐	☐
A23-16 Can you reduce acidified ammonium metavanadate with zinc and observe the sequence of colours?	☐	☐	☐
A23-17 Can you measure the emf of a series of cells and compare the values with standard electrode potentials?	☐	☐	☐
A23-18 Can you determine the amount of carbonate in an indigestion tablet by back titration?	☐	☐	☐
A23-19 Can you prepare aspirin from salicylic acid and ethanoic anhydride?	☐	☐	☐
A23-20 Can you use chromatography to compare the purity of aspirin made in the lab with commercial tablets?	☐	☐	☐