SUBJECT: Chemistry

NESTON HIGH SCHOOL

KS5 CURRICULUM PLAN 2020-21

KS4 Knowledge and key skills

YEAR 12	AUTUMN 1	AUTUMN 2	SPRING 1	SPRING 2	SUMMER 1	SUMMER 2
TOPIC	Ammount of Substance/ Atomic Structure	Ammount of Substance/ Bonding/ periodicity/ Kinetics	Equilibria + Kc/ Haloalkanes/ energetics	Redox/ Alcohols/ Group 2/ Alkenes & Alkanes	Group 7/ Analytical technique	Exams/ Kinetics/ Isomerisation/ Ketones
Knowledge	The principles of a simple time of flight (TOF) mass spectrometer, limited to ionisation, acceleration to give all ions constant kinetic energy, ion drift, ion detection, data analysis. The mass spectrometer gives accurate information about relative isotopic mass and also about the relative abundance of isotopes.Electron configurations of atoms and ions up to Z = 36 in terms of shells and sub-shells (orbitals) s, p and d.	Relative atomic mass and relative molecular mass in terms of 12C.The Avogadro constant as the number of particles in a mole. The mole as applied to electrons, atoms, molecules, ions, formulas and equations. The concentration of a substance in solution, measured in mol dm−3The ideal gas equation pV = nRT with the variables in SI units.Ionic bonding involves electrostatic attraction between oppositely charged ions in a lattice.A co-ordinate (dative covalent) bond contains a shared pair of electrons with both electrons supplied by one atom.Metallic bonding involves attraction between delocalised electrons and positive ions arranged in a lattice.Pairs of electrons in the outer shell of atoms arrange themselves as far apart as possible to minimise repulsion. Lone pair—lone pair repulsion is greater than lone pair—bond pair repulsion, which is greater than bond pair—bond pair repulsion. The effect of electron pair repulsion on bond angles.	Reactions can be endothermic or exothermic. Enthalpy change (∆H) is the heat energy change measured under conditions of constant pressure. Standard enthalpy changes refer to standard conditions, ie 100 kPa and a stated temperature (eg ∆H298ΘThe heat change, q, in a reaction is given by the equation q = mc∆T where m is the mass of the substance that has a temperature change ∆T and a specific heat capacity c. **Hess's law.Many chemical reactions are reversible. In a reversible reaction at equilibrium: forward and reverse reactions proceed at equal rates the concentrations of reactants and products remain constant Le Chatelier's principle. Le Chatelier's principle can be used to predict the effects of changes in temperature, pressure and concentration on the position of equilibrium in homogeneous reactions. A catalyst does not affect the position of equilibrium.**	Oxidation is the process of electron loss and oxidising agents are electron acceptors. Reduction is the process of electron gain and reducing agents are electron donors. The rules for assigning oxidation states.The trends in atomic radius, first ionisation energy and melting point of the elements Mg–Bathe reactions of the elements Mg–Ba with water. The use of magnesium in the extraction of titanium from TiCl4 The relative solubilities of the hydroxides of the elements Mg–Ba in water. Mg(OH)2 is sparingly soluble. The use of Mg(OH)2 in medicine	The trends in electronegativity and boiling point of the halogens.The trend in oxidising ability of the halogens down the group, including displacement reactions of halide ions in aqueous solution. The trend in reducing ability of the halide ions, including the reactions of solid sodium halides with concentrated sulfuric acid. The use of acidified silver nitrate solution to identify and distinguish between halide ions. The trend in solubility of the silver halides in ammonia. **Content** Opportunities for skills development The reaction of chlorine with water to form chloride ions and chlorate(I) ions. The reaction of chlorine with water to form chloride ions and oxygen. Appreciate that society assesses the advantages and disadvantages when deciding if chemicals should be added to water supplies. The use of chlorine in water treatment. Appreciate that the benefits to health of water treatment by chlorine outweigh its toxic effects. The reaction of chlorine with cold, dilute, aqueous NaOH and uses of the solution formed.Mass spectrometry can be used to determine the molecular formula of a compound.	Aldehydes are readily oxidised to carboxylic acids. Chemical tests to distinguish between aldehydes and ketones including Fehling's solution and Tollens' reagent. Aldehydes can be reduced to primary alcohols, and ketones to secondary alcohols, using NaBH4 in aqueous solution. These reduction reactions are examples of nucleophilic addition. The nucleophilic addition reactions of carbonyl compounds with KCN, followed by dilute acid, to produce hydroxynitriles. Aldehydes and unsymmetrical ketones form mixtures of enantiomers when they react with KCN followed by dilute acid. The hazards of using KCN.Optical isomerism is a form of stereoisomerism and occurs as a result of chirality in molecules, limited to molecules with a single chiral centre. An asymmetric carbon atom is chiral and gives rise to optical isomers (enantiomers), which exist as non super-imposable mirror images and differ in their effect on plane polarised light. A mixture of equal amounts of enantiomers is called a racemic mixture (racemate).
Skills	•Describe how a time of flight mass spectrometer works•Identify elements and calculate relative atomic mass from mass spectroscopy data •Give the electron structure of atoms and ions in terms of s, p and d sub-shells •Using mass of substance and amount in moles•use concentration, volume and amount of substance in a solution.	• Use the ideal gas equation.• explain the difference between empirical and molecular formulae• find empirical formula from data • find molecular formula from the empirical formula and relative molecular mass.•describe the structure of ionic compounds • explain the properties of ionic compounds using an understanding of ionic bonding•describe the nature of covalent bonds, including co-ordinate and multiple bonds•describe the nature of metallic bonding• explain using VSEPR theory the shapes	•Define enthalpy change and standard conditions•Define standard enthalpy changes of combustion and formation.•Calculate ∆H for reactions using calorimetry experiment data.•calculate enthalpy changes using mean bond enthalpies•draw and interpret Maxwell–Boltzmann distribution curves.•explain how and why temperature affects the rate of reactions using Maxwell–Boltzmann distributions.•explain how changes in temperature, pressure and concentration affect the position of a system at equilibrium•write an expression for Kc for a homogeneous equilibrium, including its units •calculate the moles and concentration of reagents at equilibrium•calculate the value of Kc•predict qualitatively how the value of Kc will change, if at all, as the position of an equilibrium moves as conditions are changed.•draw and name halogenoalkanes •write equations and mechanisms for reactions of halogenoalkanes with OH- , CN– and NH3	•determine oxidation states •write redox half equations •combine redox half equations to produce full equations• know and explain trends in atomic radius, first ionisation energy and melting point from Mg–Ba•describe and write equations for the reactions of Mg–Ba with water •describe how thermal and catalytic cracking are completed and the types of compounds that are produced•write equations for the formation of halogens with alkenes•write equations and give conditions for the production of alcohols by hydration of alkenes •outline the mechanism for formation of ethanol from reaction of ethene with steam with an acid catalyst•write an equation, and justify conditions for the production of ethanol by fermentation of glucose•compare the two methods of producing ethanol•explain the meaning of the term biofuel•evaluate the use of ethanol as a biofuel •show using equations how ethanol made by fermentation can be regarded as carbon neutral but that in reality it is not.	•describe and explain the trends down Group 7 in electronegativity and boiling points •describe and explain the trends in oxidising power of the halogens•describe and explain the trends in reducing power of the halide ions•evaluate advantages and disadvantages of adding chemicals to water•carry out test-tube reactions in the specification to distinguish alcohols, aldehydes, alkenes and carboxylic acids, and interpret observations from these reactions.•identify functional groups from infra-red spectra	•define structural isomerism and stereoisomerism•draw the structure of and name chain, position and functional group isomers•explain the cause of E–Z isomerism•draw the structure of and name E–Z isomers (using Cahn–Ingold–Prelog priority rules).•explain the cause of optical isomerism •identify molecules that exhibit optical isomerism/that are optically active. •draw pairs of optical isomers in 3D •describe how enantiomers affect plane polarised light •explain what a racemic mixture is, how they can be formed, and their effect on plane polarised light•know how to distinguish aldehydes and ketones •write equations, know reagents and conditions and outline the mechanism to reduce aldehydes and ketones to alcohols with NaBH4 •write equations, know reagents and conditions and outline the mechanism for reaction of aldehydes
Key Vocab	Moles/ concentration/ avagadros/ relative moleular mass. Time of flight/ ionise/ detection/ relative	Periodicity/ group/ trend/ ionsation/ pressure/ VSEPR/ coordinate/ empirical/ molecular	Exothermic/ endothermic/ enthalpy/ conditions/ distributions/ calorimetry/ combustion/ neutralisation	Osidation/ hydration/ alkene/ alkane/ reduction/ oxidation/ catalytic	Halide/ acidification/ electronegativity/ displacement/ halogen/ IR/ alcohol	Polarised/ aldehhyde/ ketone/ aqueous/ enantiomsers/ chiral center

YEAR 13	SUMMER 2	SUMMER 1	SPRING 2	SPRING 1	AUTUMN 2	AUTUMN 1
TOPIC		Syntheisis and analysis	Thermodynamics/ Aqueous inorganic	Redox/ transition metals	Amines/ amino acids/ DNA/ periodicity/ Rates/ Ketones	Kp/ Aromatics/ Acids & bases/
Knowledge		Chromatography can be used to separate and identify the components in a mixture. Types of chromatography Separation depends on the balance between solubility in the moving phase and retention by the stationary phase. Retention times and Rf values are used to identify different substances. The use of mass spectrometry to analyse the components separated by GC.Appreciation that scientists have developed a range of analytical techniques which together enable the structures of new compounds to be confirmed. Nuclear magnetic resonance (NMR) gives information about the position of 13C or 1H atoms in a molecule. 13C NMR gives simpler spectra than 1H NMR. The use of the δ scale for recording chemical shift. Chemical shift depends on the molecular environment. Integrated spectra indicate the relative numbers of 1H atoms in different environments. 1H NMR spectra are obtained using samples dissolved in deuterated solvents or CCl4 The use of tetramethylsilane (TMS) as a standard.	Lattice enthalpy can be defined as either enthalpy of lattice dissociation or enthalpy of lattice formation.Born–Haber cycles are used to calculate lattice enthalpies electron affinity∆H, whilst important, is not sufficient to explain feasible change.The concept of increasing disorder (entropy change, ∆S).∆S accounts for the above deficiency, illustrated by physical changes and chemical changes. The balance between entropy and enthalpy determines the feasibility of a reaction given by the relationship: ∆G = ∆H − T∆S (derivation not required). For a reaction to be feasible, the value of ∆G must be zero or negative.In aqueous solution, the following metal-aqua ions are formed: [M(H2O)6]2+, limited to M = Fe and Cu [M(H2O)6]3+, limited to M = Al and Fe The acidity of [M(H2O)6]3+ is greater than that of [M(H2O)6]2+ Some metal hydroxides show amphoteric character by dissolving in both acids and bases (eg hydroxides of Al3+).	IUPAC convention for writing half-equations for electrode reactions. The conventional representation of cells.Cells are used to measure electrode potentials by reference to the standard hydrogen electrode. The importance of the conditions when measuring the electrode potential, E (Nernst equation not required). Standard electrode potential, EΘ, refers to conditions of 298 K, 100 kPa and 1.00 mol dm−3 solution of ions. Standard electrode potentials can be listed as an electrochemical series.Electrochemical cells can be used as a commercial source of electrical energy. Cells can be non-rechargeable (irreversible), rechargeable or fuel cells.Fuel cells are used to generate an electric current and do not need to be electrically recharged.The electrode reactions in an alkaline hydrogen–oxygen fuel cell The benefits and risks to society associated with using these cells.Transition metal characteristics of elements Ti–Cu arise from an incomplete d sub-level in atoms or ions. The characteristic properties include: complex formation formation of coloured ions variable oxidation state catalytic activity. A ligand is a molecule or ion that forms a co-ordinate bond with a transition metal by donating a pair of electrons. A complex is a central metal atom or ion surrounded by ligands. Co-ordination number is number of co-ordinate bonds to the central metal atom or ion.2O, NH3 and Cl– can act as monodentate ligands. The ligands NH3 and H2O are similar in size and are uncharged. Exchange of the ligands NH3 and H2O occurs without change of co-ordination number (eg Co2+ and Cu2+). Substitution may be incomplete (eg the formation of [Cu(NH3)4(H2O)2]2+). The Cl– ligand is larger than the uncharged ligands NH3 and H2O	The rate of a chemical reaction is related to the concentration of reactants by a rate equation The orders m and n are restricted to the values 0, 1, and 2. The rate constant k varies with temperature as shown by the equation: k = Ae-Ea/RT where A is a constant, known as the Arrhenius constant, Ea is the activation energy and T is the temperature in K.The reactions of Na and Mg with water. The trends in the reactions of the elements Na, Mg, Al, Si, P and S with oxygen, limited to the formation of Na2O, MgO, Al2O3, SiO2, P4O10, SO2 and SO3 The trend in the melting point of the highest oxides of the elements Na–S The reactions of the oxides of the elements Na–S with water, limited to Na2O, MgO, Al2O3, SiO2, P4O10, SO2 and SO3, and the pH of the solutions formed. The structures of the acids and the anions formed when P4O10, SO2 and SO3 react with water.Primary aliphatic amines can be prepared by the reaction of ammonia with halogenoalkanes and by the reduction of nitriles. Aromatic amines, prepared by the reduction of nitro compounds, are used in the manufacture of dyes.	The equilibrium constant Kp is deduced from the equation for a reversible reaction occurring in the gas phase.Kp is the equilibrium constant calculated from partial pressures for a system at constant temperature.An acid is a proton donor.A base is a proton acceptor.Acid–base equilibria involve the transfer of protons.The conversion of hydrogen ions in aqueous solution covers a very wide range. Therefore, a logarithmic scale, the pH scale, is used as a measure of hydrogen ion concentration.Water is slightly dissociated. Kw is derived from the equilibrium constant for this dissociation.The value of Kw varies with temperature. Weak acids and weak bases dissociate only slightly in aqueous solution. Ka is the dissociation constant for a weak acid. pKa = −log10 Ka Typical pH curves for acid–base titrations in all combinations of weak and strong monoprotic acids and bases.
Skills		•devise synthetic routes, with up to four steps, to make specific organic compounds using the reactions in the course •explain why processes are designed to avoid solvents, non-hazardous starting materials and have steps with high atom economy.•understand the use of TMS and the δ scale for chemical shift •understand the use of deuterated solvents or CCl4 •use the n+1 rule to deduce spin-spin splitting patterns of adjacent, non-equivalent protons in aliphatic compounds •deduce the structure of compounds using 1H NMR to deduce structures including the number, position, relative intensity and splitting of signals •deduce the structure of compounds using 13C NMR to deduce structures including the number and position of signals. •describe the similarities and differences between thin-layer, column and gas chromatography •explain how chromatography works •use retention times and Rf values to identify substances • describe the use of mass spectroscopy to analyse substances separated by gas chromatography	•define lattice enthalpy (formation and dissociation), enthalpy of formation, ionisation enthalpy, enthalpy of atomisation, bond .Draw and use Born–Haber cycles to find missing values of enthalpy changes•describe entropy in terms of disorder •predict whether reactions have an increase or decrease in entropy •calculate the entropy change for a reaction •calculate the Gibbs free-energy change for a reaction at a given temperature•determine whether a reaction is feasible at a given temperature•calculate the temperature at which a reaction becomes feasible •sketch examples of octahedral, tetrahedral, square planar and linear complexes•explain why transition metal complexes are coloured•the hydrolysis of metal-aqua ions in aqueous solution giving acidic solutions •explain why [M(H2O)6]3+ ions are more acidic than [M(H2O)6]2+ ions •describe and explain reactions of [M(H2O)6]2+ (M = Cu, Fe) and [M(H2O)6]3+ (M = Al, Fe) with the bases OH−, NH3, CO32−	•use cell notation to represent •use the electrochemical series to predict the direction of simple redox reactions.•calculate the EMF and cell reaction for a commercial cell given the half-equations •explain how some cells can be recharged•explain how a hydrogen fuel cell works •evaluate the benefits and risks associated with using non-rechargeable, rechargeable and fuel cells.•write the electron structure of first row transition metals and their ions.•explain the difference between, and give examples of monodentate, bidentate and multidentate ligands •explain what happens in a ligand substitution (exchange) reaction and why there may be a change in co-ordination number	•determine the values and units for rate constants given appropriate data •describe how rate constants change with temperature •perform calculations using the Arrhenius equation•plot straight line graphs of ln k versus 1/T to determine the activation energy of a reaction •use concentration-time graphs to find rates (including initial rates) •use initial rate data to determine rate equations •use rate-concentration data/graphs to find orders of reaction with respect to a reagent • link rate equations to mechanism and determine rate determining steps.•write equations for the reactions of period 3 oxides with water and describe the pH of the solutions formed •describe the structure and bonding of period 3 oxides, and link this to how they react with water.•draw the structure of and name acid anhydrides, acyl chlorides and amides •identify the products of and write equations for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides •outline the mechanism for the acylation reactions of acyl chlorides •state advantages of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin •prepare and purity an organic solid and test its purity• identify the various amines and quaternary ammonium salts formed when ammonia and amines react with halogenoalkanes •give the mechanism for reactions of ammonia and amines with halogenoalkanes •recognise the use of quaternary ammonium salts •identify the products of and write equations for acylation reactions of ammonia and amines with acyl chlorides and acid anhydrides •outline the mechanism for the acylation reactions•draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions.• describe the primary, secondary and tertiary structure of proteins, including the importance of hydrogen bonds and S-S bonds •draw the structure of peptides formed from amino acids •know that peptide link can be hydrolysed producing amino acids •identify the amino acids given when a peptide is hydrolysed •know that amino acids can be separated and identified by thin-layer chromatography, including the use of Rf values.• explain that enzymes are proteins which act through a stereospecific active site that binds to a substrate •explain how drugs, which can be designed with the aid of computers, can act to inhibit enzymes by blocking active sites, but that the correct enantiomer is required. • identify the components of DNA •explain how the two DNA strands interact with hydrogen bonds between base pairs. •describe how DNA replicates in simple	•Write an expression for Kp for a reaction and calculate the value of Kp with units •predict and justify how changes in temperature and pressure affect the position of an equilibrium, and how this may or may not affect the value of Kp •understand how a catalyst affects an equilibrium and the value of Kp. •define Bronsted–Lowry acids and bases •identify species as Bronsted–Lowry acids or bases in proton transfer reactions.• calculate pH of a strong acid from its concentration •calculate the concentration of a strong acid from its pH •calculate the pH of when a strong acid is diluted.•use Kw to find the pH of strong bases from its concentration, and vice versa •calculate the pH of water at different temperatures• write expressions for Ka for stated weak acids • convert Ka values to pKa and vice versa • calculate the pH of water at different temperatures.•describe the structure of benzene and explain how delocalisation makes benzene more stable than the theoretical cyclohexa-1,3,5-triene •use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability •explain why benzene undergoes substitution reactions in preference to addition reactions.•write equations and outline mechanisms for nitration and Friedel-Crafts acylation reactions of aromatic compounds. (including equations for the formation of electrophiles) •understand the usefulness of nitration and Friedel-Crafts acylation reactions
Key Vocab		Chromatography/ aliphatic/ deduce/ TMS/ hazardous/ analysis/ synthesis	Lattice/ feasibility/ entropy	IUPAC/ electrode/ electrolyte/ EMF/ dentate/ substitution/ co-ordinate	arrhenius/ activation/ base pairs/ polymer/ polyamide / condensation/ hydrolysis	neutralisation/ log/ expression/ pressure/ delocalised/ electrophile/ nucleophile

Key Knowledge Transfer