Curriculum Map Year 13 - Chemistry

Topic Name	Term	Content / skills developed with link to NC / exam board subject content (if applicable)	Reflection on previous learning	Progress to future learning	Global Citizenship links	Qatar National Identity links
Topic 11: Kinetics	**1**	**Student should be able to:** • be able to calculate the half-life of a reaction, using data from a suitable graph, and identify a reaction with a constant half-life as being first order • understand experiments that can be used to investigate reaction rates by i an initial-rate method, carrying out separate experiments where different initial concentrations of one reagent are used A 'clock reaction' is an acceptable approximation of this method. ii a continuous monitoring method to generate data to enable concentration-time or volume-time graphs to be plotted • understand how to: i obtain data to calculate the order with respect to the reactants (and the hydrogen ion) in the acid-catalysed iodination of propanone ii use these data to make	**I**GCSE Rates of reaction **AS LEVEL Rate of reaction**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		predictions about species involved in the rate-determining step iii deduce a possible mechanism for the reaction • understand that knowledge of the rate equations for the hydrolysis of halogenoalkanes can be used to provide evidence for SN1 and SN2 mechanisms for tertiary and primary halogenoalkane hydrolysis • be able to use calculations and graphical methods to find the activation energy for a reaction from experimental data The Arrhenius equation will be given if needed • understand the use of a solid (heterogeneous) catalyst for industrial reactions, in the gas phase, in terms of providing a surface for the reaction • CORE PRACTICALS 9a and 9b Following the rate of the iodine-propanone reaction by a titrimetric method and investigating a ‘clock reaction’ (Harcourt-Esson, iodine clock).				

		• CORE PRACTICAL 10 Finding the activation energy of a reaction				
Topic 12: Entropy and Energetics 12A: Entropy	**1**	**Student should be able to:** • understand that, since endothermic reactions can occur spontaneously at room temperature, enthalpy changes alone do not control whether reactions occur • understand entropy as a measure of disorder of a system in terms of the random dispersal of molecules and of energy quanta between molecules • understand that the entropy of a substance increases with temperature, that entropy increases as solid → liquid → gas and that perfect crystals at zero kelvin have zero entropy • be able to interpret the natural direction of change as being in the direction of increasing total entropy (positive entropy change), including gases spread spontaneously through a room • understand why entropy changes occur during i	**IGCSE States of Matter** **AS Rates of reaction**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		changes of state ii dissolving of a solid ionic lattice iii reactions in which there is a change in the number of moles from reactants to products • understand that the total entropy change of any reaction is the sum of the entropy change of the system and the entropy change of the surroundings • be able to calculate the entropy change of the system for a reaction, ∆System, given the entropies of the reactants and products • understand that the feasibility of a reaction depends on: i the balance between ∆System and ∆Surroundings, so that even endothermic reactions can occur spontaneously at room temperature ii temperature, as higher temperatures decrease the magnitude of ∆Surroundings so its contribution to ∆Stotal is less Students should be able to calculate the temperature at which a reaction is feasible.				

		Students may also use $\Delta G = \Delta H - T\Delta S\text{system}$ in answers, although this approach is not a requirement of the specification. • understand that reactions can occur if $\Delta S\text{total}$ is positive even if one of the other entropy changes is negative				
Topic 12: Entropy and Energetics 12B: Lattice energy		**Student should be able to:** • be able to define the terms: i standard enthalpy change of atomisation, $\Delta\text{at}H$ ii electron affinity iii lattice energy (as the exothermic process for the formation of one mole of an ionic solid from its gaseous ions) • be able to construct Born-Haber cycles and carry out related calculations • understand that a comparison of the experimental lattice energy value (from a Born-Haber cycle) with the theoretical value (obtained from electrostatic theory) in a particular compound indicates the degree of covalent bonding	**IGCSE States of Matter** **AS Rates of reaction**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		• understand that polarisation of anions by cations leads to some covalency in an ionic bond, based on evidence from the Born-Haber cycle • be able to define the terms ‘enthalpy change of solution, ΔsolH’ and ‘enthalpy change of hydration, ΔhydH of an ion’ • be able to use energy cycles and energy level diagrams to calculate the enthalpy change of solution of an ionic compound, using enthalpy change of hydration and lattice energy • understand the effect of ionic charge and ionic radius on the values of enthalpy change of hydration and the lattice energy of an ionic compound				
Topic 13: Chemical Equilibria	**1**	**Student should be able to:** • be able to deduce an expression for Kc, for homogeneous and heterogeneous systems, in terms of equilibrium concentrations • be able to deduce an expression for Kp for	**IGCSE Equilibrium** **AS LEVEL Equilibrium**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist,	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		homogeneous and heterogeneous systems, in terms of equilibrium partial pressures in atm • be able to calculate a value, with units where appropriate, for the equilibrium constants (Kc and Kp) for homogeneous and heterogeneous reactions, from experimental data • understand how, if at all, a change in temperature, pressure or the presence of a catalyst affects the equilibrium composition in a homogeneous or heterogeneous system • understand that the value of the equilibrium constant is not affected by changes in concentration or pressure or by the addition of a catalyst • know the effect of changing the temperature on the equilibrium constant (Kc and Kp) for both exothermic and endothermic reactions • understand that the effect of temperature on the position of equilibrium is explained using a change in the value of the equilibrium constant		Chemical Engineer, Pharmacy		

		- understand the effect of a change in temperature on i the value of ΔStotal ii the magnitude of the equilibrium constant, since ΔStotal = R lnK - be able to apply knowledge of the value of equilibrium constants to predict the extent to which a reaction takes place				
Topic 14: Acid-base Equilibria	**1**	**Student should be able to:** - understand that a Brønsted–Lowry acid is a proton donor and a Brønsted–Lowry base is a proton acceptor and that acid-base reactions involve proton transfer - be able to identify Brønsted–Lowry conjugate acid-base pairs - be able to define the term ‘pH’ - be able to calculate pH from hydrogen ion concentration - be able to calculate the concentration of hydrogen ions in a solution, in mol dm-3, from its pH, using the expression [H+] = 10-pH - understand the difference between a strong acid and	**IGCSE Acid and Alkali** **AS LELVEL Titration**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		a weak acid in terms of the degree of dissociation • be able to calculate the pH of a weak acid from Ka or pKa values, making relevant assumptions • be able to define the terms ‘pKa’ and ‘pKw’ • be able to analyse data from the following experiments: i measuring the pH of a variety of substances, including equimolar solutions of strong and weak acids, strong and weak bases, and salts ii comparing the pH of a strong and weak acid after dilution 10, 100 and 1000 times • be able to draw and interpret titration curves, using all combinations of strong and weak monoprotic and diprotic acids with bases, and apply these principles to diprotic acids and bases • be able to select a suitable indicator for a titration, using a titration curve and appropriate data • know what is meant by the term ‘buffer solution’ and				

		understand the action of a buffer solution • understand how to use a weak acid-strong base or strong acid-weak base titration curve to i demonstrate buffer action ii determine Ka from the pH at the point where half the acid is neutralised/ equivalence point • understand the importance of buffer solutions in biological environments: i buffers in cells and in blood (H_2CO_3/HCO_3^-) ii in foods to prevent deterioration due to pH change (caused by bacterial or fungal activity) • CORE PRACTICAL 11 Finding the Ka value for a weak acid.				
Topic 15: Organic Chemistry: Carbonyls, Carboxylic Acids	**1**	**Student should be able to:** • know that optical isomerism is a result of chirality in molecules with a single chiral centre • understand that optical isomerism results from chiral centre(s) in a molecule with asymmetric carbon atom(s) and that optical isomers (enantiomers) are object	**IGCSE Organic Chemistry** **AS LEVEL Haloalkanes**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		and non-superimposable mirror images and be able to draw 3D diagrams of these optical isomers • know that optical activity is the ability of a single optical isomer to rotate the plane of polarisation of plane-polarised monochromatic light in molecules containing a single chiral centre • know what is meant by the term 'racemic mixture' • be able to use data on optical activity of reactants and products as evidence for SN1 and SN2 mechanisms and addition to carbonyl compounds • carbonyl compound given data of the melting temperatures of derivatives the equation for this reaction is not required. v iodine in the presence of alkali (the iodoform test)				
Topic 15: Organic Chemistry: Carbonyls, Carboxylic Acids 15B: Carbonyl compounds	**1**	**Student should be able to:** • understand that aldehydes and ketones: i do not form intermolecular hydrogen bonds and this affects their physical properties ii can form hydrogen bonds with	**IGCSE Organic Chemistry** **AS LEVEL Haloalkanes**		Prepare for future challenges **Pride Independence and Dedication**	

		water and this affects their solubility • understand the reactions of carbonyl compounds with i Fehling's or Benedict's solution, Tollens' reagent, and acidified dichromate (VI) ions in equations, the oxidising agent can be represented as [O]. ii lithium tetrahydridoaluminate(III) (lithium aluminium hydride) in dry ether (ethoxyethane) In equations, the reducing agent can be represented by [H]. iii HCN, in the presence of KCN, as a nucleophilic addition reaction, using curly arrows, relevant lone pairs, dipoles and evidence of optical activity to show the mechanism iv 2,4-dinitrophenylhydrazine (2,4-DNPH), as a qualitative test for the presence of a carbonyl group and to identify a				
Topic 15: Organic Chemistry: Carbonyls, Carboxylic Acids 15C: Carboxylic acids	**1**	**Student should be able to:** • understand the nomenclature of carboxylic acids and be able to draw	**IGCSE Organic Chemistry** **AS LEVEL Haloalkanes**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic		

		their structural, displayed, and skeletal formulae • understand that hydrogen bonding affects the physical properties of carboxylic acids, in relation to their boiling temperatures and solubility • understand that carboxylic acids can be prepared by the oxidation of alcohols or aldehydes and the hydrolysis of nitriles • understand the reactions of carboxylic acids with i lithium tetrahydridoaluminate(III) (lithium aluminium hydride) in dry ether (ethoxyethane) ii bases to produce salts iii phosphorus(V) chloride (phosphorus pentachloride) iv alcohols in the presence of an acid catalyst		Chemist, Organic Chemist, Chemical Engineer, Pharmacy		
Topic 15: Organic Chemistry: Carbonyls, Carboxylic Acids 15D: Carboxylic acid derivatives		**Student should be able to:** • understand the nomenclature of acyl chlorides and esters and be able to draw their structural, displayed, and skeletal formulae • understand the hydrolysis reactions of esters, in acidic and alkaline solution	**IGCSE Organic Chemistry** **AS LEVEL Haloalkanes**			

		- understand how polyesters, such as terylene, are formed by condensation polymerisation reactions.				
Topic 15: Organic Chemistry: Carbonyls, Carboxylic Acids 15E: Spectroscopy and chromatography		**Student should be able to:** - be able to use data from mass spectra to i suggest possible structures of a simple organic compound given accurate relative molecular masses ii calculate the accurate relative molecular mass of a compound, given accurate relative atomic masses to four decimal places - understand that carbon-13, (13C) NMR spectroscopy provides information about the positions of 13C atoms in a molecule - be able to use data from 13C NMR spectroscopy to i predict the different environments for carbon atoms present in a molecule, given values of chemical shift, δ ii justify the number of peaks present in a 13C NMR spectrum in terms of the number of carbon atoms in different environments	**IGCSE Organic Chemistry** **AS LEVEL Haloalkanes**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy		

		• be able to use both low and high resolution proton NMR spectroscopy to: i predict the different types of proton present in a molecule, given values of chemical shift, δ ii relate relative peak areas, or ratio number of protons, to the relative numbers of 1H atoms in different environments iii deduce the splitting patterns of adjacent, non-equivalent protons using the (n+1) rule and hence suggest the possible structures for a molecule iv predict the chemical shifts and splitting patterns of the 1H atoms in a given molecule • be able to calculate Rf values from one-way chromatograms in paper and thin-layer chromatography (TLC) and understand reasons for differences in Rf values				
		•				
Topic 16: Redox Equilibria	**2**	**Student should be able to:** • understand the terms ‘oxidation’ and ‘reduction’ in terms of electron transfer and changes in oxidation	**IGCSE Equilibrium** **AS LEVEL Equilibrium Redox**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		number, applied to s-, p- and d-block elements • know what is meant by the term 'standard electrode potential,' Eo • know that the standard electrode potential, Eo, is measured in conditions of i 298 K temperature ii 100 kPa pressure of gases iii 1.00 mol dm-3 concentration of ions • understand that different methods are used to measure standard electrode potentials of i metals or non-metals in contact with their ions in aqueous solution ii ions of the same element with different oxidation numbers • CORE PRACTICAL 12 Investigating some electrochemical cells. • be able to calculate a standard emf, Eocell , by combining two standard electrode potentials • be able to write cell diagrams using the conventional representation of half-cells • understand the importance of the conditions when		Chemist, Organic Chemist, Chemical Engineer, Pharmacy		

		measuring an electrode potential, E - be able to use standard electrode potentials to predict the thermodynamic feasibility of a reaction - understand that Eo cell is directly proportional to the total entropy change and to lnK for a reaction - understand the limitations of predictions made using standard electrode potentials, in terms of kinetic stability of systems and departure from standard conditions - know that standard electrode potentials are sometimes referred to as standard reduction potentials and can be listed as an electrochemical series - understand how standard electrode potentials can be used to predict the thermodynamic feasibility of disproportionation reactions - be able to carry out both structured and unstructured titration calculations involving redox reactions, including iron (II) ions and potassium manganate (VII)				

		and sodium thiosulfate and iodine - CORE PRACTICALS 13a and 13b Carry out redox titrations with both: i iron (II) ions and potassium manganate (VII) ii sodium thiosulfate and iodine				
Topic 17: Transition Metals and their Chemistry	**2**	**Student should be able to:** - know that transition metals are d-block elements that form one or more stable ions with incompletely filled d-orbitals - be able to deduce the electronic configurations of atoms and ions of the d-block elements of Period 4 (Sc-Zn) given their atomic number and charge - understand why transition metals show variable oxidation number - know what is meant by the term 'ligand' - understand that dative (coordinate) covalent bonding is involved in the formation of complex ions - know that a complex ion is a central metal ion surrounded by ligands - understand that the colour of aqueous ions, and other	**AS LEVEL** Formulae, Equations and Amount of Substance, Shapes of molecules	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		complex ions, is a consequence of the splitting of the energy levels of the d-orbitals by ligands • understand why there is a lack of colour in some aqueous ions and other complex ions • understand that colour changes in transition metal ions may arise because of changes in i oxidation number of the ion ii ligand iii coordination number of the complex • understand that H2O, OH- and NH3 act as monodentate ligands • understand why complexes with six-fold coordination an octahedral shape has, such as those formed by metal ions with H2O, OH- and NH3 as ligands • know that transition metal ions may form tetrahedral complexes with relatively large ions such as Cl • know that square planar complexes are also formed by transition metal ions and that cis-platin is an example of such a complex which is used in cancer treatment where it is supplied as a				

		single isomer and not in a mixture with the transform • understand the terms ‘bidentate’ and ‘hexadentate’ in relation to ligands, and be able to identify examples such as NH2CH2CH2NH2 and EDTA4- • know that haemoglobin is an iron (II) complex containing a polydentate ligand and that ligand exchange occurs when an oxygen molecule bound to haemoglobin is replaced by a carbon monoxide molecule • understand redox reactions for the interconversion of the oxidation states of vanadium (+5, +4, +3 and +2), in terms of the relevant Eo values • understand, in terms of the relevant E values, that the dichromate (VI) ion, Cr2O7 2- i can be reduced to Cr3+ and Cr2+ ions using zinc in acidic conditions ii can be produced by the oxidation of Cr3+ ions using hydrogen peroxide in alkaline conditions (followed by acidification)				

		• be able to record observations and write suitable equations for the reactions of Cr3+(aq), Mn2+(aq), Fe2+(aq), Fe3+(aq), Co2+(aq), Ni2+(aq), Cu2+(aq) and Zn2+(aq) with aqueous sodium hydroxide and aqueous ammonia, including in excess • understand, in terms of the positive increase in ∆Ssystem, that the substitution of a monodentate ligand by a bidentate or hexadentate ligand leads to a more stable complex ion • know that transition metals and their compounds can act as heterogeneous and homogeneous catalysts • know that a heterogeneous catalyst is in a different phase from the reactants and that the reaction occurs at the surface of the catalyst • understand how a catalytic converter decreases carbon monoxide and nitrogen monoxide emissions from internal combustion engines by i adsorption of CO and NO molecules onto the				

		surface of the catalyst, resulting in the weakening of bonds and chemical reaction ii desorption of CO2 and N2 product molecules from the surface of the catalyst - know that a homogeneous catalyst is in the same phase as the reactants and appreciate that the catalysed reaction will proceed via an intermediate species - CORE PRACTICAL 14 The preparation of a transition metal complex.				
Topic 18: Organic Chemistry – Arenes	**2**	**Student should be able to:** - understand that the delocalised model for the structure of benzene involves overlap of p-orbitals to form π-bonds - understand why benzene is resistant to bromination, compared to alkenes, in terms of delocalisation of π-bonds in benzene compared to the localised electron density of the π-bond in alkenes	**IGCSE Organic Chemistry** **AS LEVEL Organic Chemistry (Alkenes and Alkanes)**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		• know the following reactions of benzene, limited to i oxygen in air (combustion to form a smoky flame) ii bromine, in the presence of a catalyst iii a mixture of concentrated nitric and sulfuric acids iv fuming sulfuric acid v halogenoalkanes and acyl chlorides with aluminium chloride as catalyst (Friedel-Crafts reaction) • understand the mechanism of the electrophilic substitution reactions of benzene in halogenation, nitration, and Friedel-Crafts reactions, including the generation of the electrophile • understand the reaction of phenol with bromine water and the reasons for the relative ease of this reaction compared to benzene				
Topic 19: Organic Nitrogen Compounds: Amines, Amides, Amino Acids and Proteins		**Student should be able to:** • understand the nomenclature of amides, amines and amino acids and be able to draw their structural, displayed, and skeletal formulae		**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		• understand that amines are miscible with water as a result of hydrogen bonding, and the reasons for the difference in basicity between ammonia, primary aliphatic amines, and primary aromatic amines • understand, in terms of reagents and general reaction conditions, the preparation of primary aliphatic amines: i from halogenoalkanes ii by the reduction of nitriles • know the preparation of aromatic amines by the reduction of aromatic nitrocompounds using tin and concentrated hydrochloric acid • be able to describe: i condensation polymerisation for the formation of polyamides such as nylon and proteins ii addition polymerisation, including poly(propenamide) and poly(ethenol) • be able to comment on the physical properties of polyamides and the solubility in water of the addition polymer		Chemist, Chemical Engineer, Pharmacy		

		poly(ethenol) in terms of hydrogen bonding, including soluble laundry bags or liquid-detergent capsules (liquitabs) • be able to describe experiments to investigate the characteristic behaviour of amino acids limited to i acidity and basicity and the formation of zwitterions ii effect of aqueous solutions on plane-polarised monochromatic light iii formation of peptide bonds by condensation polymerisation • CORE PRACTICAL 15 Analysis of some inorganic and organic unknowns. •				
Topic 19: Organic Nitrogen Compounds: Amines, Amides, Amino Acids and Proteins	**2**	**Student should be able to:** • be able to deduce the empirical formulae, molecular formulae and structural formulae from data drawn from combustion analysis, element percentage composition, characteristic reactions of functional groups, infrared spectra, mass spectra and NMR	**AS LEVEL: Mass Spectra**	**Future career prospect:** Chemical technician, Analytical Chemist, Synthetic Chemist, Organic Chemist, Chemical Engineer, Pharmacy	Prepare for future challenges **Pride Independence and Dedication**	**Sustainability**: responsibility and creativity. **Conscious thinking** about my **Actions**

		spectra (both 13C and proton) • understand methods of increasing the length of the carbon chain in a molecule using magnesium to form Grignard reagents and the reactions of the latter with carbon dioxide and with carbonyl compounds in dry ether • be able to use knowledge of organic chemistry contained given in this specification to solve problems such as: i predicting the properties of unfamiliar compounds containing one or more of the functional groups included in the specification and explain these predictions ii planning reaction schemes of up to four steps, recalling familiar reactions and using unfamiliar reactions given sufficient information iii selecting suitable practical procedures for carrying out reactions involving compounds with functional groups included in this specification iv identifying appropriate control				

		measures to reduce risk based on data of hazards • CORE PRACTICAL 16 The preparation of aspirin. • understand the following techniques used in the preparation and purification of organic compounds: i refluxing ii purification by washing, including with water and sodium carbonate solution iii solvent extraction iv recrystallisation v drying vi distillation vii steam distillation viii melting temperature determination ix boiling temperature determination				
		•				