English Chemistry Curriculum Map

May 2016

	KS1	Lower KS2	Upper KS2	KS3	KS4 (higher content emboldened)	KS5	Higher Education (Year 1 and 2)
Atomic structure and the periodic table				**Existence of atoms, elements and compounds**	Atomic structure; protons, neutrons electrons and electron shells, and their relative masses, charges and sizes; relative atomic mass, charge and isotopes; how the theory of atomic structure has changed over time	**Atomic orbitals**; structure and atomic configuration of atoms, ions and isotopes in terms of s, p and d orbitals and subshells. How electronic configurations (drawn as 'electrons in a box') affect the chemical properties of an element	**Quantum chemistry**; wave properties of electrons, Schrödinger equation, potential energy boxes
							Electronic structure of atom including shape of orbitals
							Magneto-chemistry
				The periodic table: principles underpinning it; periods and groups; metals and non-metals; how patterns in reactions can be predicted	Structure of the periodic table; elements arranged relating to electronic and atomic structure	**Structure of the periodic table by proton number**; s, p and d	
					Trends in the periodic table; Explain the reactivity and general properties as related to the atomic structure of groups 1, 7 and 0; between metals and non-metals	**Trends down groups** related to electronic structure, including Group 1 and 2 (atomic radii, reactivity, characteristic reactions) and Group 7; (electronegativity; disproportion, reducing power, identification with silver nitrate)	**Trends in s, p and d blocks, including ionisation energy, formation and reaction of common compounds, anomalous behaviour of the first element in each group**
							Periodicity- Hard and soft acid-base theory (HSAB)
						Trends across periods related to electronic structure, including ionisation energy, melting points, atomic radii, electronegativity	**S-block**; electron deficient compounds and organometallic chemistry and structure
							F block trends; lanthanides and actinides
Inorganic chemistry					Transition metal properties	**Transition metal properties as related to electronic structure;** Complex ion formation, coloured ions, catalysis, variable oxidation state due to partially filled d orbitals	**Inorganic chemistry in biological systems**; metallo-enzyme chemistry, photobiology, metals in medicine
						Complex ions; coordination number, charge on the complex and oxidation state of the metal	**Crystal field theory and valence field theory**; Metal-ligand and metal-metal bonding in terms of molecular orbital theory
						Ligand substitution reactions; coordinate bonds, equations for ligand substitution reactions, including aqua complexes and redox reactions	**Mechanisms of reactions of metal complexes**
Properties of matter	**Changing materials by applying physical force**	**Changing the state of materials by applying temperature;** including evaporation/ condensation in the water cycle	**State change is reversible**	**Particle model**: Including relating to states of matter, and conservation of mass in changes of state; And in relating bulk properties of states to particles including gas pressure and diffusion	The main features of the particle model in terms of states of matter; and use to predict the state of substances under given conditions		
		Compare and group materials as solid, liquid, gas			**Limitations of the inelastic sphere model**		**Real and ideal gases; liquids and solutions**
Bonding					Bonds formation by transferring or sharing electrons; dot and cross diagrams for simple, ionic and covalent structure		**Linear combination of atomic orbitals (LCAO) to form bonds (molecular orbitals)**
					Types of bonding (double/ single bonds; ionic/covalent) and how bonding relates to bulk properties, including in carbon allotropes	**Covalent bonding, dative bonding and double bonds in terms of electrons and orbitals**. Giant covalent compounds and their properties as a consequence of bonding	
						Aromatic compounds; structure and bonding of benzene	**Solid state**; Crystal structure and symmetry, lattices, diffraction, crystallography
						Ionic and metallic bonds; dot and cross diagrams of electron transfer; electrostatic forces; how this relates to their bulk properties	**Metallic and ionic solid state structure**; radius ratio rule, ionic model; lattice energies and Born Haber cycles
					Relative strengths of intra and inter- molecular bonds as related to state changes	**Intermolecular bonding;** The relative strengths of different types of intermolecular bonding, including hydrogen bonding, and their effect on bulk properties	
						Electronegativity; as measured by the Pauling scale; how it relates to bonding and bulk properties	
						Shape of molecules; work out using VSEPR theory	**Walsh diagrams for predicting orbital geometries of small molecules**
						Isomers; structural, geometric and stereoisomers, including chirality	**Symmetry, group theory**, assignment of point groups, classification of axes
Materials	Describe the physical properties of everyday materials; **Compare and group everyday materials with respect to physical properties**		Compare and group together materials using more advanced physical properties (solubility, conductivity)	**Physical properties of useful materials:** metals and non-metals, ceramics, polymers and composites	Compare the physical properties of materials and justify their use; corrosion, know the composition of different alloys		**Inorganic materials chemistry**; chemistry of functional materials and interfaces, synthesis
	Identify and compare the physical properties of everyday materials and relate these to purpose; know the difference between the object and the materials from which it was made		Give reasons, based on evidence from fair and comparative tests, for particular uses of everyday materials		Nanomaterial; nano-scale, describe how the surface area to volume relationship affects properties and how this dictates their uses		**Materials chemistry; polymerisation**; synthesis and chemical properties of polymers and macromolecules
							Materials chemistry; Nano-scale chemistry
							Surfactants, micelles and meso-phases; stability in dispersions
Earth science		**Compare and group rocks based on simple physical properties**		**Earth and rocks:** the composition and structure of the Earth; the rock cycle and formation of igneous, sedimentary and metamorphic rocks			
		Formation; fossils and soils (from rocks and organic matter)					
Chemical changes; redox and acids			**Irreversible reactions lead to formation (baking, burning, and bicarbonate of soda)**	**Chemical reactions:** in terms of rearrangements of atoms; including combustion, thermal decomposition, oxidation, displacement reactions; conservation of mass in reactions	Reactions take place via electron or proton transfer, or electron sharing		
				Acids, bases, the pH scale and indicators: reactions of acids with metals and reactions of acids with alkalis; chemical properties of metal and non-metal oxides with respect to acidity.	Reactions of acids; neutralisation, reaction with carbonates, reactivity of metals and acid as related to the tendency of metal to form positive ions		
					Acids as sources of hydrogen ions; alkalis contain hydroxide ions in solution	**Bronsted-lowry acid theory**; formation of acid base conjugate pairs	
					Difference between weak/strong acids and dilute/ concentrated acids; recall how pH is related to hydrogen ion concentration	**Determination of equilibrium constants for weak and strong acids**; also equilibrium constant for the ionic product of water	**Structure and bonding as related to pKa**
						Buffer solutions minimise changes in pH	
					Redox: reduction and oxidation in terms of loss and gain of oxygen **Redox in terms of electrons lost and gained**	**Redox as electrons lost and gained; applied to s, p and d block elements**; oxidation numbers, oxidising/reducing reagents disproportionation	
					Electrolysis; common species at the cathode and anode, electrolysis of binary ionic compounds, competing reactions	**Electrode potentials and their uses**; the standard hydrogen electrode, the electrochemical series and the reactivity of metals	**Electrochemical processes and potentials**, polarography, electric properties of materials and solids
					Chemical cells produce a potential difference until the reactants are used up	**Electrode potentials;** Structure of electrochemical cells	
					Hydrogen fuel cells		
Organic chemistry					Carbon can form 4 covalent bonds, and this property allows it to form a vast array of natural and synthetic compounds		
					Functional groups in organic compounds; (limited to alkanes, alkenes, alcohols and carboxylic acids) and structural formula of these	**Homologous series** (limited to alkanes, branched alkanes, cycloalkanes, halogenoalkanes, alkenes, alcohols, carboxylic acids, esters, aldehydes, ketones); draw using molecular, structural, displayed and skeletal forms	**Reactions and structure of alkanes, alkenes and alkynes**
							Reactions and structure of aromatic compounds; nucleophilic/electrophilic substitution, lithiation, ortho/para/ meta directing
					Functionality can be used to predict reactions; simple reactions for the functional groups listed above (combustion, addition across a double bond, and oxidation of alcohols)	**Types of organic reactions**: addition, elimination and substitution (nucleophilic and electrophilic), oxidation and reduction, halogenation, hydrolysis, addition and condensation polymerisation, combustion, transesterification, cracking/ reforming; **link bond polarity to enthalpy and reactivity**	**Reactions and structure of carbonyl compounds;** aldehydes, ketones, carboxylic acids, esters, acetals, ketals, imines, enamines, enols, enolates
							Reactions and structure of alcohols, thiols, ethers, sulfonate esters, amines, alkyl halides, organometallics
						Organic synthesis; reactions of alkanes, alkenes, halogenoalkanes, alcohols, arenes, ketones, aldehydes, phenols, acyl chlorides, carboxylic acids, esters, amines, amino acids, amides, nitriles. Use the above reactions to work out synthetic routes to some of these species.	**Synthetic techniques in organic and biological systems**; retro-synthesis, asymmetric synthesis, synthetic pathways and total synthesis
							Drug discovery and synthesis; design, targets, shape and synthesis, computational chemistry
					Fractional distillation and cracking to make useful materials; carbon compounds as a finite feedstock and fuel	**Alkanes as fuels**; balance word equation for their combustion; use in cracking and reforming processes	
					Principles of addition polymerisation, including monomers, repeat units and naturally occuring polymers	**Polymerisation; Addition polymerisation and condensation polymerisation** Uses of polymers and prevalence of polymers in biological systems (DNA and proteins)	
					Condensation polymerisation; repeat units, importance of functional groups		
						Nucleophiles and electrophiles	**Mechanisms; Classification of substitution and elimination reactions** (Sn1 and Sn2), reactive intermediates, nucleophiles and electrophiles
						Mechanisms for radical, nucleophilic and electrophilic reactions; both addition and substitution	**Advanced mechanisms**; pericyclic, asymmetric, radical
Rates, equilibria and thermo-dynamics					Rates: factors that affect frequency and energy of collisions; activation energy; interpretion of simple rate graphs	**Define rate of reaction, rate constant and order of reaction**	**Mechanisms within rates**; Precursor states, common mechanisms, transition state theory, chain reactions
				Catalysts	Catalysts; how they affect activation energy	**Heterogeneous catalysis**; including examples of industrial use	**Different types of catalysis** (homo- and hetero-geneous) including enzyme catalysis; examples, applications, mechanisms
							Solid state kinetics; Rates of absorption and desorption, surface active models
						Determination of rate equations, orders of reaction and the rate limiting step by taking tangents from graphs; know qualitatively the effect of changes in temperature on the rate constant	**Derivations of simple rate equations for complex reactions**; rate equations and constants; calculating rates; steady state and equilibrium approximations
					Interpret graphs of reaction vs rate; trade off between rate of production of a desired product and position of equilibrium; commercially used conditions relate to cost, raw materials, rate and control	**Collision theory, Boltzmann distribution and activation energy**, factors that lower the activation energy or increase the rate; in relation to enthalpy profile diagrams and bond strengths; and related to changes in the Boltzmann distribution	**Kinetic theory of gases** and related calculations of mean speeds and degrees of freedom; using kinetic theory to derive the Boltzmann distribution
				Energy changes in changes of state			**Describing motion using degrees of freedom, matrices and determinants**
				Definitions of exothermic and endothermic reactions	How bond breaking and making relates to exothermic and endothermic reactions; reaction profiles	**Enthalpy** of combustion, reaction, formation, solution and average bond enthalpies; calculate using Hess's cycle and DeltaH= mc DeltaT	**Statistical thermodynamics**; laws of thermodynamics (zero-th, first, second, third), statistical definitions of internal energy, entropy and chemical potential; calculations
					Relative bond energies as related to exothermic and endothermic reactions		
						Entropy; qualitative description of disorder in a system (solid, liquid, gas); calculate change in the entropy of a system	**Deriving the Boltzmann entropy formula**
						Feasibility using entropy and enthalpy	**Electrochemistry and thermodynamics;** Ionic strength of ions (activity), redox potentials
					Principles of dynamic equilibrium	**Calculating the equilibrium constant**, and the effect of different factors (concentration, pressure and temperature) on the equilibrium constant in reversible reactions; using le Chatelier's principle.	
					Fertilisers; Haber process, industrial production and lab synthesis of fertilisers		**Applications**; Thermodynamics of equilibrium and of organic reactions; thermodynamics of gases, liquids and solids, and of interfaces; biological equilibrium, thermodynamics and reactions
					Predict how changing conditions leads to a changing equilibrium position		
Chemical symbols, units and calcu-lations				**Representing elements and reactions using chemical symbols and formulae**	Balancing simple chemical equations and ionic equations; use state symbols; calculate empirical formulae	**Balancing ionic and molecular chemical equations**	**Units, conventions, nomenclature**
					Write balanced half and full ionic equations		
					Explain why one reaction pathway is chosen over another; all factors considered		
					Quantitative interpretations of balanced equations, conservation of mass		
					Calculating per cent yield, atom economy and theoretical yield	**Yields; atom economies and per cent yields; theoretical and actual**	
					Moles and determining the stoichiometry of an equation; know relationship between volume, mass and molar concentration; and the relationship between molar volume, volume and mass in gases	**Stoichiometric amounts from reacting masses, mole concentrations, volumes of gases**, empirical and molecular formula	
						Definitions of relative atomic, formula, isotopic and molecular mass	
Chemical analysis and prep-aration						**Titration calculations**; including those with transition metals	**Classical techniques**; titrations, gravimetry, colorimetry
							Analytical techniques; sampling, data treatment, statistics, quantitative analysis, quality assurance
		Mixing and dissolving are **reversible reactions**	**Identification and definitions of impure (mixtures) and pure substances**	Melting points and chromatography to define if a substance is pure	**Chromatography**; Liquid-gas, TLC, use for separating mixtures	
		Mixtures may be separated by filtering, sieving, evaporation	Impure substances can be separated by filtration, evaporation, distillation and chromatography	Separation techniques; filtration, crystallisation, advanced chromatography, simple and fractional distillation		**Chromatography;** TLC, HPLC, GC, LC, ion exchange chromatography, size exclusion chromatography, detectors
			Dissolving			**The nature of electric and magnetic fields**
				Analytical techniques; identification of common gases, flame tests, tests for aqueous ions, and a type of instrumental analysis, including interpreting an instrumental result in tabular or chart form	**Modern analytical techniques**; IR as causing bonds to vibrate, NMR and spin-spin coupling; be able to interpret spectra of both	**Modern spectroscopy**; NMR spectroscopy, IR spectroscopy, mass spec, UV-VIS spectroscopy; as applied to organic and inorganic species
					Mass spectroscopy; calculate relative atomic mass, how MS works, interpret a mass spec.	**Rotational and vibrational spectroscopy, Raman spectroscopy**; using molecular rotations and vibrations
							Electronic transitions and spectra; Atomic absorbance/ emission spec, ICP-MS and x-ray fluorescence; quantum transitions leading to spectroscopy; excited states; apply this knowledge to transition complexes and organic molecules
							Crystallography and diffraction; lasers
Chemistry in the environ-ment and industry			**The reactivity series** and its application to metal purification	Extraction and purification in the industrial processes; including electrolysis **and biological methods**			
			Composition of the atmosphere; carbon cycle; climate change	Composition and evolution of the atmosphere; evidence, causes, prevention and effects of climate change and pollutants			Atmospheric chemistry
				Resources; recycling and life cycle assessments			**Natural resources and pollution**

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