Topic	Done
Chemical equilibrium	
recognise that chemical systems may be open (allowing matter and energy to be exchanged with the surroundings) or closed (allow energy, but not matter, to be exchanged with the surroundings)	
understand that physical changes are usually reversible, whereas only some chemical reactions are reversible	
appreciate that observable changes in chemical reactions and physical changes can be described and explained at an atomic and molecular level	
symbolise equilibrium equations by using $\rightleftharpoons$ in balanced chemical equations	
understand that, over time, physical changes and reversible chemical reactions reach a state of dynamic equilibrium in a closed system, with the relative concentrations of products and reactants defining the position of equilibrium	
explain the reversibility of chemical reactions by considering the activation energies of the forward and reverse reactions	
analyse experimental data, including constructing and using appropriate graphical representations of relative changes in the concentration of reactants and product against time, to identify the position of equilibrium	
Factors that affect equilibrium	
explain and predict the effect of temperature change on chemical systems at equilibrium by considering the enthalpy change for the forward and reverse reactions	
explain the effect of changes of concentration and pressure on chemical systems at equilibrium by applying collision theory to the forward and reverse reactions	
apply Le Châtelier's principle to predict the effect changes of temperature, concentration of chemicals, pressure and the addition of a catalyst have on the position of equilibrium and on the value of the equilibrium constant	
Equilibrium constants	
understand that equilibrium law expressions can be written for homogeneous and heterogeneous systems and that the equilibrium constant (Kc), at any given temperature, indicates the relationship between product and reactant concentrations at equilibrium	
deduce the equilibrium law expression from the equation for a homogeneous reaction and use equilibrium constants (Kc), to predict qualitatively, the relative amounts of reactants and products (equilibrium position)	
deduce the extent of a reaction from the magnitude of the equilibrium constant	
use appropriate mathematical representation to solve problems, including calculating equilibrium constants and the concentration of reactants and products	

Properties of acids and bases	
understand that acids are substances that can act as proton (hydrogen ion) donors and can be classified as monoprotic or polyprotic depending on the number of protons donated by each molecule of the acid	
distinguish between strong and weak acids and bases in terms of the extent of dissociation, reaction with water and electrical conductivity and distinguish between the terms strong and concentrated for acids and bases	
pH scale	
understand that water is a weak electrolyte and the self-ionisation of water is represented by $K_w = [H+][OH–]$; K_w can be used to calculate the concentration of hydrogen ions from the concentration of hydroxide ions in a solution	
understand that the pH scale is a logarithmic scale and the pH of a solution can be calculated from the concentration of hydrogen ions using the relationship pH = –log10 [H+]	
use appropriate mathematical representation to solve problems for hydrogen ion concentration [H+(aq)], pH, hydroxide ion concentrations [OH–(aq)] and pOH	
Brønsted-Lowry model	
recognise that the relationship between acids and bases in equilibrium systems can be explained using the Brønsted-Lowry model and represented using chemical equations that illustrate the transfer of hydrogen ions (protons) between conjugate acid-base pairs	
recognise that amphiprotic species can act as Brønsted-Lowry acids and bases	
identify and deduce the formula of the conjugate acid (or base) of any Brønsted-Lowry base (or acid)	
appreciate that buffers are solutions that are conjugate in nature and resist a change in pH when a small amount of an acid or base is added; Le Châtelier's principle can be applied to predict how buffer solutions respond to the addition of hydrogen ions and hydroxide ions	
Dissociation constants	
recognise that the strength of acids is explained by the degree of ionisation at equilibrium in aqueous solution, which can be represented with chemical equations and equilibrium constants (K_a)	
determine the expression for the dissociation constant for weak acids (K_a) and weak bases (K_b) from balanced chemical equations	
analyse experimental data to determine and compare the relative strengths of acids and bases	
use appropriate mathematical representation to solve problems, including calculating dissociation constants (K_a and K_b) and the concentration of reactants and products	
Acid-base indicators	
understand that an acid-base indicator is a weak acid or a weak base where the components of the conjugate acid-base pair have different colours; the acidic form is of a different colour to the basic form	
explain the relationship between the pH range of an acid-base indicator and its pK_a value	
recognise that indicators change colour when the pH = pK_a and identify an appropriate indicator for a titration, given equivalence point of the titration and pH range of the indicator	
Volumetric analysis	
distinguish between the terms *end point* and *equivalence point*	
recognise that acid-base titrations rely on the identification of an equivalence point by measuring the associated change in pH, using chemical indicators or pH meters, to reveal an observable end point	
sketch the general shapes of graphs of pH against volume (titration curves) involving strong and weak acids and bases. Identify and explain their important features, including the intercept with pH axis, equivalence point, buffer region and points where pK_a = pH or pK_b = pOH	
use appropriate mathematical representations and analyse experimental data and titration curves to solve problems and make predictions, including using the mole concept to calculate moles, mass, volume and concentration from volumetric analysis data	

Redox reactions	
recognise that a range of reactions, including displacement reactions of metals, combustion, corrosion and electrochemical processes, can be modelled as redox reactions involving oxidation of one substance and reduction of another substance	
understand that the ability of an atom to gain or lose electrons can be predicted from the atom's position in the periodic table, and explained with reference to valence electrons, consideration of energy and the overall stability of the atom	
identify the species oxidised and reduced, and the oxidising agent and reducing agent, in redox reactions	
understand that oxidation can be modelled as the loss of electrons from a chemical species, and reduction can be modelled as the gain of electrons by a chemical species; these processes can be represented using balanced half-equations and redox equations (acidic conditions only)	
deduce the oxidation state of an atom in an ion or compound and name transitional metal compounds from a given formula by applying oxidation numbers represented as roman numerals	
use appropriate representations, including half-equations and oxidation numbers, to communicate conceptual understanding, solve problems and make predictions	
Electrochemical cells	
understand that electrochemical cells, including galvanic and electrolytic cells, consist of oxidation and reduction half-reactions connected via an external circuit that allows electrons to move from the anode (oxidation reaction) to the cathode (reduction reaction)	
Galvanic cells	
understand that galvanic cells, including fuel cells, generate an electrical potential difference from a spontaneous redox reaction which can be represented as cell diagrams including anode and cathode half-equations	
recognise that oxidation occurs at the negative electrode (anode) and reduction occurs at the positive electrode (cathode) and explain how two half-cells can be connected by a salt bridge to create a voltaic cell (examples of half-cells are Mg, Zn, Fe and Cu and their solutions of ions)	
describe, using a diagram, the essential components of a galvanic cell; including the oxidation and reduction half-cells, the positive and negative electrodes and their solutions of their ions, the flow of electrons and the movement of ions, and the salt bridge	
Standard electrode potential	
determine the relative strength of oxidising and reducing agents by comparing standard electrode potentials	
recognise that cell potentials at standard conditions can be calculated from standard electrode potentials; these values can be used to compare cells constructed from different materials	
recognise the limitation associated with standard reduction potentials	
use appropriate mathematical representation to solve problems and make predictions about spontaneous reactions, including calculating cell potentials under standard condition	
Electrolytic cells	
understand that electrolytic cells use an external electrical potential difference to provide the energy to allow a non-spontaneous redox reaction to occur, and appreciate that these can be used in small-scale and industrial situations, including metal plating and the purification of copper	
predict and explain the products of the electrolysis of a molten salt and aqueous solutions of sodium chloride and copper sulfate. Explanations should refer to *Eø* values, the nature of the electrolyte and the concentration of the electrolyte	
describe, using a diagram, the essential components of an electrolytic cell; including source of electric current and conductors, positive and negative electrodes, and the electrolyte	