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**Knowledge Rich Curriculum Plan**

Science – Chemistry

Year 13



| **Science** **Year 13 Chemistry**  | **Unit: Thermodynamics** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Key Definitions** | * Students will know that first ionisation energy is the enthalpy change when each atom in one mole of gaseous atoms loses one electron to form one mole of gaseous 1+ ions
* Students will know that second ionisation energy is the enthalpy change when each ion in one mole of gaseous 1+ ions loses one electron to form one mole of gaseous 2+ ions.
* Students will know that first electron affinity is the enthalpy change when each atom in one mole of gaseous atoms gains one electron to form one mole of gaseous 1– ions.
* Students will know that second electron affinity is the enthalpy change when each ion in one mole of gaseous 1– ions gains one electron to form one mole of gaseous 2– ions.
* Students will know that enthalpy of atomisation is the enthalpy change when one mole of gaseous atoms is produced from an element in its standard state.
* Students will know that hydration enthalpy is the enthalpy change when one mole of gaseous ions become hydrated (dissolved in water).
* Students will know that enthalpy of solution is the enthalpy change when one mole of an ionic solid dissolves in an amount of water large enough so that the dissolved ions are well separated and do not interact with each other.
* Students will know that lattice enthalpy of formation is the enthalpy change when one mole of a solid ionic compound is formed from into its constituent ions in the gas phase
* Students will know that lattice enthalpy of dissociation is the enthalpy change when one mole of a solid ionic compound is broken up into its constituent ions in the gas phase
* Students will know that enthalpy of vaporisation is the enthalpy change when one mole of a liquid is turned into a gas
* Students will know that enthalpy of fusion is the enthalpy change when one mole of a solid is turned into a liquid
* Students will know how to represent the different enthalpy changes using equations
 |  | * ***Students need to already know that enthalpy of formation is the enthalpy change when one mole of a substance is formed from its constituent elements with all substances in their standard states***
* ***Students need to already know that enthalpy of combustion is the enthalpy change when one mole of a substance undergoes complete combustion in oxygen with all substances in standard states***
* ***Students need to already know that enthalpy of neutralisation is the enthalpy change when 1 mole of water is formed in a reaction between an acid and alkali under standard conditions***
* ***Students need to already know that bond dissociation enthalpy is the enthalpy change when one mole of covalent bonds is broken in the gaseous state.***
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| **Lesson:** **Enthalpy of Solution Calculations** | * Students will know how to apply Hess' Law to Enthalpy of Solution Calculations
 |  | * ***Students already need to know that enthalpy of solution is the enthalpy change when one mole of an ionic solid dissolves in an amount of water large enough so that the dissolved ions are well separated and do not interact with each other.***
* ***Students need to already know how to represent enthalpy of solution using equations***
* ***Students need to already know that Hess's Law states the overall enthalpy change of a reaction is independent to the route taken***
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| **Lesson:** **Born-Haber Cycles** | * Students will know that lattice enthalpy of a compound is an indication of the strength of ionic bonding, the greater the magnitude of the lattice enthalpy the stronger the bonding
* Students will know that generally speaking compounds with smaller ions and/or ions with higher charges have stronger attractions and so greater lattice enthalpy
* Students will know that the lattice enthalpy of a compound can be found using a Born-Haber cycle, and that this is often called an "experimental value" as the data used is determined by experiments
* Students will know that lattice enthalpy is usually represented as the enthalpy of formation in a Born-Haber cycle
* Students will know that when drawing Born-Haber cycles, it's important to:
* 1) Draw a separate step for every enthalpy change
* 2) Second and third electron affinities are endothermic and should be drawn going up not down
* 3) Numerical values should be written next to every step.
* Students will know how to construct Born-Haber cycles
* Students will know how to use Born-Haber cycles to complete calculations
* Students will know how to compare experimental lattice enthalpy values to theoretical lattice enthalpy values
 | La | * ***Students need to already know that lattice enthalpy of formation is the enthalpy change when one mole of a solid ionic compound is formed from into its constituent ions in the gas phase***
* ***Students need to already know that lattice enthalpy of dissociation is the enthalpy change when one mole of a solid ionic compound is broken up into its constituent ions in the gas phase***
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| **Lesson:** **Entropy** | * Students will know that entropy (S) is a measure of disorder
* Students will know that the greater the disorder, the greater the entropy
* Students will know that entropy is measured in J mol^-1 K^-1
* Students will know that, generally speaking, gases have the most entropy and solids have the least entropy
* Students will know that there is a tendency for entropy to increase
* Students will know that as temperature increases entropy increases
* Students will know how to qualitatively predict changes in entropy
* Students will know how to calculate entropy change for a reaction, using:

Entropy change = (Sum of entropy of the products) - (Sum of entropy of the reactants)* Students will know that when there is an increase in entropy, entropy change is positive
* Students will know that when there is a decrease in entropy, entropy change is negative
* Students will know that, generally speaking, an increase in entropy makes a reaction more favourable
 | Entropy: a measure of disorder |  | Entropy change of vaporisation of water using a kettle |
| **Lesson:** **Gibbs Free Energy** | * Students will know that entropy change is not sufficient to explain whether a reaction is feasible or not
* Students will know that enthalpy change is not sufficient to explain whether a reaction will take place or not.
* Students will know that Gibbs free energy combines both enthalpy change and entropy change to work out if a reaction is feasible or not
* Students will know that Gibbs free energy can be calculated using:

∆G = ∆H - T∆S* Students will know that for a reaction to be feasible, the value for ∆G must be zero or negative
* Students will know how to use the relationship to determine how ∆G varies with temperature
* Students will know how to use the relationship to determine the temperature at which a reaction becomes feasible
* Students will know how to determine ∆S and ∆H from a graph of ∆G against T
 |  | * ***Students need to already know how to calculate entropy values***
* ***Students need to already know that enthalpy is a measure of change in energy, where -ve enthalpy shows an exothermic reaction and +ve enthalpy shows an endothermic reaction***
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| **Science****Year 13 Chemistry**  | **Unit: Rate Equations** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Recap of AS Kinetics** | * Students will know that the reaction rate is the change in concentration of a reactant or product per unit time
* Students will know that Maxwell-Boltzmann distribution curve shows the energy of particles in a gas
* Students will know how to interpret Maxwell-Boltzmann distribution curves, and adapt them for changes in conditions
* Students will know how to draw tangents to curves
* Students will know how to calculate rates of reactions from graphs
 |  | * ***Students need to already know that collision theory states that for a chemical reaction to take place reactants must collide with each other with sufficient energy (activation energy) to react with each other***
* ***Students need to already know how to explain the effects of concentration, temperature, gas pressure, surface area and catalyst on rates of reaction***
 |  |
| **Lesson:** **Rate Equations and Orders** | * Students will know that the order of reaction with respect to the reactant tells us the effect the reactant has on the rate of reaction
* Students will know that if the order of reaction with respect to a reactant is 0, then the reactant has no effect on the rate of reaction
* Students will know that if the order of reaction with respect to a reactant is 1, then the reaction rate is proportional to the concentration of the reactant
* Students will know that if the order of reaction with respect to a reactant is 2, then the reaction rate is proportional to the concentration of the reactant squared
* Students will know that for any reaction, the rate equation can be written as:

Rate = k [A]^m [B] ^n* where k is the rate constant, m is the order of the reaction with respect to A and n is the order of the reaction with respect to B
* The overall order of the reaction is m+n (the sum of the orders with respect to the reactants)
* Students will know that in some cases, catalysts can be included in rate equations
* Students will know that the only thing that affects the value of k is temperature
* Students will know how to determine the units of k
* Students will know how to write a rate equation for different reactions
 |  | * ***Students need to already know that [A] represents the concentration of A***
* ***Students need to already know that the units of concentration are mol dm^-3***
 | Determining order of a reaction |
| **Lesson:** **Finding Orders using Initial Rates** | * Students will know that initial rates of reaction refer to the rate of reaction at the start of the reaction
* Students will know how to use initial rates of reaction to determine the order of a reaction in terms of the reactants
* Students will know how to calculate a value for k using the rate equation
 |  | * ***Students need to already know that if the order of reaction with respect to a reactant is 0, then the reactant has no effect on the rate of reaction***
* ***Students need to already know that if the order of reaction with respect to a reactant is 1, then the reaction rate is proportional to the concentration of the reactant***
* ***Students need to already know that if the order of reaction with respect to a reactant is 2, then the reaction rate is proportional to the concentration of the reactant squared***
* ***Students need to already know that for any reaction, the rate equation can be written as:***

***Rate = k [A]^m [B] ^n**** ***where k is the rate constant, m is the order of the reaction with respect to A and n is the order of the reaction with respect to B***
* ***The overall order of the reaction is m+n (the sum of the orders with respect to the reactants)***
 |  |
| **Lesson:** **The Arrhenius Equation** | * Students will know that the Arrhenius equation shows the link between the rate constant, activation energy and temperature
* Students will know that the symbols in the Arrhenius equation are:

k = rate constantA = Arrhenius constantEa = activation energyR = gas constantT = temperature* Students will know that the Arrhenius constant has the same unit as the rate constant
* Students will know how to use the Arrhenius equation to calculate k, A, Ea, R or T
* Students will know that graphical analysis can be performed to determine values from the Arrhenius equation.
* Students will know that if ln K is plotted again+ 1/T:

the intercept is equal to ln Athe gradient is equal to -Ea/R |  | * ***Students need to already know how to determine the units of the rate constant***
* ***Students need to already know how to calculate gradients from graphs***
 |  |
| **Lesson:** **Concentration-time graphs and rate-concentration graphs** | * Students will know that concentration-time graphs can be used to determine the order of the reagent in the reaction:
* - a straight line shows zero order
* - a curve shows either first or second order
* Students will know that rate-concentration graphs are more useful at telling us what order a reaction is:
* - a horizontal line shows that the reaction is zero order with respect to the reagent
* - a rising straight line shows that the reaction is first order with respect to the reagent
* - an upwards curve shows that the reaction is second order with respect to the concentration of the reagent.
* Students will know that rate-concentration graphs can be produced using experimental data
* Students will know that the initial rates method for determining rate-concentration graphs involves carrying out several reactions starting with different concentrations, and measuring the initial rate of each one
* Students will know that the continuous rates method for determining rate concentration graphs involves measuring the rate at several points during one reaction
 |  | * ***Students need to already know how to calculate gradients from graphs***
 |  |
| **Lesson:** **Required Practical 7** | * Students will know how to measure the rate of reaction using an initial rate method and a continuous monitoring method
 |  | * ***Students need to already know how to determine order of reaction using graphs***
 |  |

| **Science****Year 13 Chemistry**  | **Unit: Equilibrium Constant Kp** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Partial Pressures and Mole Fractions** | * Students will know that mole fractions of a substance can be determined by using:
* mole fraction of substance A = moles of substance A / total moles of all substances
* Students will know that partial pressure is calculated using:
* partial pressure of substance A = mole fraction of A x total pressure
* Students will know how to use this in determining the partial pressures of substances at equilibrium
* Students will know how to write Kp expressions
* Students will know how to determine the units of Kp
 |  | * ***Students need to already know how to determine the number of moles at equilibrium***
 |  |
| **Lesson:** **Kp Calculations** | * Students will know how to perform calculations involving Kp
* Students will know how to predict qualitative effects of changes in temperature on the value of Kp
* Students will know that catalysts don't affect the value of the equilibrium constant
 |  |  |  |

| **Science** **Year 13 Chemistry**  | **Unit: Electrode Potentials** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **AS recap on Redox** | * Students will know that oxidation states are the charge an atom would have if it was an ion
* Students will know that the oxidation state for an element is always zero
* Students will know that the total of all the oxidations tates must always equal the overall charge on the species
* Students will know that (nearly always) Hydrogen has an oxidation state of +1, and oxygen has an oxygen state of -2
* Students will know how to determine the oxidation state of atoms in certain species
* Students will know how to write half equations
* Students will know how to combine half equations
* Students will know how to determine what has been oxidised or reduced during a reaction
 |  | * ***Students need to already know that with half equations:***

***1) Os are balanced with H2O******2) Hs are balanced with H+**** ***Students need to already know that oxidation is loss of electrons and reduction is gain of electrons***
 |  |
| **Lesson:** **Electrode Potential** | * Students will know that when a piece of metal is dipped into a solution of its metal ions an equilibrium is set up.
* Students will know that in this equilibrium, there is a tendency for metal to form positive ions and go into solution, as well as a tendency for the metal ions in solution to gain electrons and form metals
* Students will know that the position of the equilibrium set up depends on the metal
* Students will know that a metal dipped into a solution of its ions is called a half-cell (or electrode)
* Students will know that the potential of a half cell can't be measured directly, it must be connected to another half-cell of known potential
* Students will know that two half-cells combined together produces an electrochemical cell
* Students will know that the standard hydrogen electrode is assigned the potential of 0 V, and is known as the primary standard
* Students will know that to set up an electrochemical cell:

1) The two metals are joined with a wire2) the two solutions are joined with a salt bridge (ions can flow through the salt bridge)3) a voltmeter is included to allow the potential difference to be measured* Students will know that a salt bridge can either be a piece of filter paper soaked with a solution of unreactive ions or a tube containing unreactive ions in an agar gel
* Students will know that standard conditions are:

1) cell concentration: 1 mol dm^-3 of the ions involved in the half equation2) cell temperature: 298 K3) cell pressure: 100 kPa (only for half cells with gases)* Students will know that a standard hydrogen electrode is set up with a supply of hydrogen gas passing over a platinum catalyst
 | Electrochemical cell: the combination of two half-cells | * ***Students need to already know that ions are formed by losing or gaining electrons***
* ***Students need to already know that reactivity of metals is linked to the tendency of a metal to form its ion***
 | Investigating changing conditions on EMF of an electrochemical cell |
| **Lesson:** **Representing Cells** | * Students will know that when representing cells, a | represents a phase boundary, whilst a || represents a salt bridge
* Students will know that the most oxidised species are near the salt bridge in the middle
* Students will know that the convention is for the more positive half cell will be the right hand electrode
* Students will know how to represent cells using standard convention
* Students will know that to calculate emf you subtract the potential of the left cell from the potential of the right cell
 |  | * ***Students need to already know that the most oxidised species will be the ones with the highest oxidation state***
 |  |
| **Lesson:** **Required Practical 8** | * Students will know how to set up electrochemical cells, and use them to measure the EMF (potential difference)
 |  |  |  |
| **Lesson:** **The Electrochemical Series** | * Students will know that the electrochemical series is a list of electrode potentials in order of decreasing potential
* Students will know that when two half equations are put together, the one with the more positive potential gets electrons
* Students will know how to write equations to represent electrochemical cells using the electrochemical series to help
 |  | * ***Students need to already know that electrochemical cells are made up of 2 half cells connected together***
 |  |
| **Lesson:** **Commercial Cells** | * Students will know that electrochemical cells can be used as a commercial source of electrical energy
* Students will know that a battery is more than one cell joined together
* Students will know that a non-rechargeable cell is a cell which reaches an emf of 0 volts as the chemicals are used up
* Students will know that zinc-carbon and alkaline cells are examples of non-rechargeable cells
* Students will know that in rechargeable cells the reactions are reversible, meaning that they can be reversed by applying an external current and regenerate the chemicals
* Students will know that examples of rechargeable cells are lithium ion, lead-acid and nickel cadmium
* Students will know that for a lithium cell, the electrode reactions are:

positive electrode: Li+ + CoO2 + e- --> Li+[CoO2}-negative electrode: Li --> Li+ + e-* Students will know that fuel cells have a continuous supply of the chemicals to the cell so they don't run out of chemicals or need recharging
* Students will know that hydrogen-oxygen fuel cells are the main example of fuel cells
* Students will know that the reaction that takes place in a hydrogen fuel cell is:

H2 + 2OH- --> 2H2O + 2e-O2 + 2H2O + 4e- --> 4OH-* Students need to know that the benefits of using cells are that they are portable sources of electrical energy, whilst risks are waste issues
* Students will know that the benefits of non-rechargeable cells are that they are cheap
* Students will know that benefits of using rechargeable cells are that there is less waste, it's cheaper in the long run and there is lower environmental impact
* Students will know that benefits of hydrogen fuel cells are that the only waste product is water, they don't need re-charging and they're very efficient. Risks include constant supply of fuels, hydrogen is flammable and explosive, hydrogen is usually made using fossil fuels and that they're expensive
 |  | * ***Students need to already know that cells are used to produce potential difference (from GCSE Physics)***
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| **Science** **Year 13 Chemistry**  | **Unit: Acids and Bases** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Bronsted-Lowry Acids and Bases** | * Students will know that H+ ions are protons
* Students will know that an acid is a proton donor
* Students will know that a base is a proton acceptor
* Students will know that acid-base equilibria involves the transfer of protons
 | Bronsted-Lowry Acid: a proton donorBronsted Lowry Base: a proton acceptor | * ***Students need to already know that all acids ionise and produce H+ ions***
 |  |
| **Lesson:** **pH** | * Students will know that pH is a logarithmic scale
* Students will know that the pH scale is a measure of H+ concentration
* Students will know that pH is calculated using the equation: pH = -log10[H+]
* Students will know the H2SO4 is diprotic, so it releases two H+ ions when it ionises
* Students will know how to calculate the pH of a strong acid using the equation
* Students will know how to convert between concentration of H+ ions and pH
 | Diprotic: an acid that ionises to form 2 H+ ions | * ***Students need to already know that pH is a measure of how acidic a solution is***
* ***Students will know that square brackets are used to represent concentration***
 |  |
| **Lesson:** **Ionic product of water** | * Students will know that water is slightly dissociated, producing H+ and OH- ions
* Students will know that Kw is derived from the equilibrium constant for the dissociation of water
* Students will know that since the concentration of water is so much larger than that of H+ and OH- it effectively remains constant, meaning we can remove it from the expression
* Students will know that Kw = [H+][OH-]
* Students will know that Kw varies with temperature
* Students will know how to use Kw to calculate the pH of water (in this case, [H+]=[OH-], so Kw = [H+]2)
* Students will know that water is always neutral, even if the pH isn’t 7. This is due to it having the same concentration of H+ and OH- in solution
* Students will know how to use Kw to calculate the pH of a strong base from its concentration.
 |  | * ***Students need to already know that concentration is represented using square brackets***
* ***Students need to already know how to construct equilibrium constant expressions***
 |  |
| **Lesson:** **Weak Acids and Bases** | * Students will know that weak bases only partly dissociate in solution
* Students will know that Ka is the dissociation constant for a weak acid, and that the expression follows the same rules for representing Kc
* Students will know that when completing calculations involving Ka, we can say that [H+] = [A-], as the acid molecules dissociate evenly
* Students will know that pKa = -log10Ka
* Students will know how to complete calculations involving Ka, pH and concentration of acids
* Students will know how to convert Ka and pKa
 |  | * ***Students need to already know that a weak acid is an acid that only dissociates partly in solution***
* ***Students need to already know that carboxylic acids are examples of weak acids***
 | Uses of indicators |
| **Lesson:** **pH Curves and Titrations** | * Students will know how to sketch pH curves for acid-base titrations in all combinations of weak and strong monoprotic acids and bases
* Students will know that the equivalence point is the point at which neutralisation takes place
* Students will know that the equivalence point is found on a pH curve where there is a steep and sudden increase in pH
* Students will know that the indicator used to recognise the end point of a titration must change colour in the pH range where the equivalence point occurs.
* Students will know that pKa can be found by reading off half the volume of the equivalence point.
 |  | * ***Students need to already know how to carry out an acid-base titration***
* ***Students need to already know how to complete titration calculations***
 | Acid-base titrations |
| **Lesson:** **Buffer Action** | * Students will know that a buffer solution maintains a constant pH despite addition of acid or base
* Students will know that acidic buffer solutions contain a weak acid and the salt of the weak acid
* Students will know that basic buffer solutions contain a weak base and salt of that weak base
* Students will know that an acidic buffer can be made by reacting a weak acid with an excess of a base, or through mixing a salt with the weak acid
* Students will know that when an acid is added to an acidic buffer the H+ ions react with the salt ions, removing the H+ from the solution so minimising the effect of the extra H+ ions added
* Students will know that when an alkali is added to an acidic buffer solution, the acid reacts with the alkali to remove it from the solution.
* Students will know how to complete calculations involving acidic buffer solutions and pH.
 | Buffer: a solution that maintains a constant pH |  |  |