

Chemistry DP Course Overview, UWC Thailand 2017-2018

All units taught in grades 11 and 12 are continuously being developed and improved to best meet the needs of the students at UWCT. Therefore, the following overview is only a reflection of current plans for the course. Some changes to these course overviews may occur as a result of planning done throughout the academic year.

Grade	Time Frame	Unit number and title	Approaches To learning skills taught / learnt / developed in this unit	Content (topics / knowledge/ subject specific skills)	Connections to TOK	Summative assessment
11	1. 3 weeks 11.1. 1 week	1. Stoichiometry SL and HL Integrated with unit 11.1 Uncertainties and errors in measurement and results SL and HL	<p>Communication and social skills: Students will complete group presentations on the Gas Laws.</p> <p>Communication skills: Students will learn how to set out mathematical solutions in a clear manner.</p> <p>Inquiry: Students will determine the molar mass of butane through scientific investigation.</p>	<p>Unit 1</p> <p>1.1</p> <p>Understandings:</p> <ul style="list-style-type: none"> • Atoms of different elements combine in fixed ratios to form compounds, which have different properties from their component elements. • Mixtures contain more than one element and/or compound that are not chemically bonded together and so retain their individual properties. • Mixtures are either homogeneous or heterogeneous. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of chemical equations when reactants and products are specified. • Application of the state symbols (s), (l), (g) and (aq) in equations. • Explanation of observable changes in physical properties and temperature during changes of state. <p>1.2</p> <p>Understandings:</p> <ul style="list-style-type: none"> • The mole is a fixed number of particles and refers to the amount, n, of substance. • Masses of atoms are compared on a scale relative to ^{12}C and are expressed as relative atomic mass (A_r) and relative formula/molecular mass (M_r). • Molar mass (M) has the units g mol^{-1}. • The empirical formula and molecular formula of a compound give the simplest ratio and the actual number of atoms present in a molecule respectively. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Calculation of the molar masses of atoms, ions, molecules and formula units. • Solution of problems involving the relationships between the number of particles, the amount of substance in moles and the mass in grams. • Interconversion of the percentage composition by mass and the empirical formula. 	<p>“Assigning numbers to the masses of the chemical elements has allowed chemistry to develop into a physical science.”</p> <p>Set HW to research: why are atomic masses measured relative to ^{12}C? Why is mathematics so effective in describing the natural world?</p>	<p>Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments</p>

- Determination of the molecular formula of a compound from its empirical formula and molar mass.
- Obtaining and using experimental data for deriving empirical formulas from reactions involving mass changes.

1.3

Understandings:

- Reactants can be either limiting or excess.
- The experimental yield can be different from the theoretical yield.
- Avogadro's law enables the mole ratio of reacting gases to be determined from volumes of the gases.
- The molar volume of an ideal gas is a constant at specified temperature and pressure.
- The molar concentration of a solution is determined by the amount of solute and the volume of solution.
- A standard solution is one of known concentration.

Applications and skills:

- Solution of problems relating to reacting quantities, limiting and excess reactants, theoretical, experimental and percentage yields.
- Calculation of reacting volumes of gases using Avogadro's law.
- Solution of problems and analysis of graphs involving the relationship between temperature, pressure and volume for a fixed mass of an ideal gas.
- Solution of problems relating to the ideal gas equation.
- Explanation of the deviation of real gases from ideal behaviour at low temperature and high pressure.
- Obtaining and using experimental values to calculate the molar mass of a gas from the ideal gas equation.
- Solution of problems involving molar concentration, amount of solute and volume of solution.
- Use of the experimental method of titration to calculate the concentration of a solution by reference to a standard solution.

Unit 11

11.1

Understandings:

- Qualitative data includes all non-numerical information obtained from observations not from measurement.
- Quantitative data are obtained from measurements, and are always associated with random errors/uncertainties, determined by the apparatus, and by human limitations such as reaction times.
- Propagation of random errors in data processing shows the impact of the uncertainties on the final result.
- Experimental design and procedure usually lead to systematic errors in measurement, which cause a deviation in

				<p>a particular direction.</p> <ul style="list-style-type: none"> • Repeat trials and measurements will reduce random errors but not systematic errors. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Distinction between random errors and systematic errors. • Record uncertainties in all measurements as a range (+) to an appropriate precision. • Discussion of ways to reduce uncertainties in an experiment. • Propagation of uncertainties in processed data, including the use of percentage uncertainties. • Discussion of systematic errors in all experimental work, their impact on the results and how they can be reduced. • Estimation of whether a particular source of error is likely to have a major or minor effect on the final result. • Calculation of percentage error when the experimental result can be compared with a theoretical or accepted result. • Distinction between accuracy and precision in evaluating results. 		
11	<p>2. 2 weeks</p> <p>12. 0.5 week</p>	<p>2. Atomic Structure SL and HL</p> <p>12. Atomic Structure HL only</p>	<p>Communication skills: students will explicitly consider the characteristics of good scientific communication when completing their first lab report.</p> <p>Inquiry: Students will determine the empirical formula of MgO through scientific investigation.</p>	<p>Unit 2</p> <p>2.1</p> <p>Understandings</p> <ul style="list-style-type: none"> • Atoms contain a positively charged dense nucleus composed of protons and neutrons (nucleons). • Negatively charged electrons occupy the space outside the nucleus. • The mass spectrometer is used to determine the relative atomic mass of an element from its isotopic composition. <p>Applications and skills</p> <ul style="list-style-type: none"> • Use of the nuclear symbol notation to deduce the number of protons, neutrons and electrons in atoms and ions. • Calculations involving non-integer relative atomic masses and abundance of isotopes from given data, including mass spectra. <p>2.2</p> <p>Understandings</p> <ul style="list-style-type: none"> • Emission spectra are produced when photons are emitted from atoms as excited electrons return to a lower energy level. • The line emission spectrum of hydrogen provides evidence for the existence of electrons in discrete energy levels, which converge at higher energies. • The main energy level or shell is given an integer number, n, and can hold a maximum number of electrons, $2n^2$. • A more detailed model of the atom describes the division of the main energy level into s, p, d and f sub-levels of successively higher energies. • Sub-levels contain a fixed number of orbitals, regions of space where there is a high probability of finding an electron. 	<p>"No subatomic particles can be (or will be) directly observed. Which ways of knowing do we use to interpret indirect evidence, gained through the use of Technology?"</p> <p>Set students a research homework 'how do we know what we know about atoms?'</p>	<p>Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments</p>

				<p>•Each orbital has a defined energy state for a given electronic configuration and chemical environment and can hold two electrons of opposite spin.</p> <p>Applications and skills:</p> <ul style="list-style-type: none"> •Description of the relationship between colour, wavelength, frequency and energy across the electromagnetic spectrum. •Distinction between a continuous spectrum and a line spectrum. •Description of the emission spectrum of the hydrogen atom, including the relationships between the lines and energy transitions to the first, second and third energy levels. •Recognition of the shape of an s atomic orbital and the p_x, p_y and p_z atomic orbitals. •Application of the Aufbau principle, Hund's rule and the Pauli exclusion principle to write electron configurations for atoms and ions up to $Z = 36$. <p>Unit 12 12.1 Understandings</p> <ul style="list-style-type: none"> •In an emission spectrum, the limit of convergence at higher frequency corresponds to the first ionization energy. •Trends in first ionization energy across periods account for the existence of main energy levels and sub-levels in atoms. •Successive ionization energy data for an element give information that shows relations to electron configurations. <p>Applications and skills</p> <ul style="list-style-type: none"> •Solving problems using $E = h\nu$. •Calculation of the value of the first ionization energy from spectral data which gives the wavelength or frequency of the convergence limit. •Deduction of the group of an element from its successive ionization energy data. •Explanation of the trends and discontinuities in first ionization energy across a period. 		
11	<p>4. 3 weeks</p> <p>14. 2 weeks</p>	<p>4. Chemical bonding and structure SL and HL</p> <p>14. Chemical bonding and structure HL only</p>	<p>Teamwork and collaboration: groups of students will research explanations for the different properties of ionic compounds and teach the other groups through a "marketplace" activity.</p> <p>Teamwork and collaboration: student presentations of homework answers.</p> <p>Local and global contexts and research skills: students will explain the science behind ozone</p>	<p>Unit 4 4.1 Understandings:</p> <ul style="list-style-type: none"> • Positive ions (cations) form by metals losing valence electrons. • Negative ions (anions) form by non-metals gaining electrons. • The number of electrons lost or gained is determined by the electron configuration of the atom. • The ionic bond is due to electrostatic attraction between oppositely charged ions. • Under normal conditions, ionic compounds are usually solids with lattice structures. <p>Applications and skills:</p>	<p>Set HW task: What evidence do we have for the existence of ozone depletion? Which evidence is direct and which is indirect?</p>	<p>Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments</p>

			<p>depletion and research into global initiatives to reduce the hole in the ozone layer.</p>	<ul style="list-style-type: none"> • Deduction of the formula and name of an ionic compound from its component ions, including polyatomic ions. • Explanation of the physical properties of ionic compounds (volatility, electrical conductivity and solubility) in terms of their structure. <p>4.2 Understandings:</p> <ul style="list-style-type: none"> • A covalent bond is formed by the electrostatic attraction between a shared pair of electrons and the positively charged nuclei. • Single, double and triple covalent bonds involve one, two and three shared pairs of electrons respectively. • Bond length decreases and bond strength increases as the number of shared electrons increases. • Bond polarity results from the difference in electronegativities of the bonded atoms. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of the polar nature of a covalent bond from electronegativity values. <p>4.3 Understandings:</p> <ul style="list-style-type: none"> • Lewis (electron dot) structures show all the valence electrons in a covalently bonded species. • The “octet rule” refers to the tendency of atoms to gain a valence shell with a total of 8 electrons. • Some atoms, like Be and B, might form stable compounds with incomplete octets of electrons. • Resonance structures occur when there is more than one possible position for a double bond in a molecule. • Shapes of species are determined by the repulsion of electron pairs according to VSEPR theory. • Carbon and silicon form giant covalent/network covalent structures. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of Lewis (electron dot) structure of molecules and ions showing all valence electrons for up to four electron pairs on each atom. • The use of VSEPR theory to predict the electron domain geometry and the molecular geometry for species with two, three and four electron domains. • Prediction of bond angles from molecular geometry and presence of nonbonding pairs of electrons. • Prediction of molecular polarity from bond polarity and molecular geometry. • Deduction of resonance structures, examples include but are not limited to C_6H_6, CO_3^{2-} and O_3. • Explanation of the properties of giant covalent compounds in 		
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terms of their structures.

4.4

Understandings:

- Intermolecular forces include London (dispersion) forces, dipole-dipole forces and hydrogen bonding.
- The relative strengths of these interactions are London (dispersion) forces < dipole-dipole forces < hydrogen bonds.

Applications and skills

- Deduction of the types of intermolecular force present in substances, based on their structure and chemical formula.
- Explanation of the physical properties of covalent compounds (volatility, electrical conductivity and solubility) in terms of their structure and intermolecular forces

4.5

Understandings:

- A metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons.
- The strength of a metallic bond depends on the charge of the ions and the radius of the metal ion.
- Alloys usually contain more than one metal and have enhanced properties.

Applications and skills:

- Explanation of electrical conductivity and malleability in metals.
- Explanation of trends in melting points of metals.
- Explanation of the properties of alloys in terms of non-directional bonding.

Unit 14

14.1

Understandings:

- Covalent bonds result from the overlap of atomic orbitals. A sigma bond (σ) is formed by the direct head-on/end-to-end overlap of atomic orbitals, resulting in electron density concentrated between the nuclei of the bonding atoms. A pi bond (π) is formed by the sideways overlap of atomic orbitals, resulting in electron density above and below the plane of the nuclei of the bonding atoms.
- Formal charge (FC) can be used to decide which Lewis (electron dot) structure is preferred from several. The FC is the charge an atom would have if all atoms in the molecule had the same electronegativity. $FC = (\text{Number of valence electrons}) - \frac{1}{2}(\text{Number of bonding electrons}) - (\text{Number of non-bonding electrons})$. The Lewis (electron dot) structure with the atoms having FC values closest to zero is preferred.
- Exceptions to the octet rule include some species having incomplete octets and expanded octets.

				<ul style="list-style-type: none"> • Delocalization involves electrons that are shared by/between all atoms in a molecule or ion as opposed to being localized between a pair of atoms. • Resonance involves using two or more Lewis (electron dot) structures to represent a particular molecule or ion. A resonance structure is one of two or more alternative Lewis (electron dot) structures for a molecule or ion that cannot be described fully with one Lewis (electron dot) structure alone. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Prediction whether sigma (σ) or pi (π) bonds are formed from the linear combination of atomic orbitals. • Deduction of the Lewis (electron dot) structures of molecules and ions showing all valence electrons for up to six electron pairs on each atom. • Application of FC to ascertain which Lewis (electron dot) structure is preferred from different Lewis (electron dot) structures. • Deduction using VSEPR theory of the electron domain geometry and molecular geometry with five and six electron domains and associated bond angles. • Explanation of the wavelength of light required to dissociate oxygen and ozone. • Description of the mechanism of the catalysis of ozone depletion when catalysed by CFCs and NO_x. <p>14.2</p> <p>Understandings:</p> <ul style="list-style-type: none"> • A hybrid orbital results from the mixing of different types of atomic orbitals on the same atom. <p>Applications:</p> <ul style="list-style-type: none"> • Explanation of the formation of sp^3, sp^2 and sp hybrid orbitals in methane, ethene and ethyne. • Identification and explanation of the relationships between Lewis (electron dot) structures, electron domains, molecular geometries and types of hybridization. 		
11	5. 2 weeks 15. 2 weeks	Topic 5: Energetics/thermochemistry SL and HL 15. Energetics/thermochemistry HL only	Thinking skills: practice IA analysis and evaluation sections.	Unit 5 5.1 Understandings: <ul style="list-style-type: none"> • Heat is a form of energy. • Temperature is a measure of the average kinetic energy of the particles. • Total energy is conserved in chemical reactions. • Chemical reactions that involve transfer of heat between the system and the surroundings are described as endothermic or exothermic. • The enthalpy change (ΔH) for chemical reactions is indicated in kJ mol^{-1}. • ΔH values are usually expressed under standard conditions, 	Explore during calorimetry lab evaluation: Many assumptions are made in calorimetry to simplify calculations. They can prove to produce data that is inconsistent with theory. To what extent should we use them, if we wish to have "true" data?	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments

given by ΔH° , including standard states.

Applications and skills:

- Calculation of the heat change when the temperature of a pure substance is changed using $q = mc\Delta T$.
- A calorimetry experiment for an enthalpy of reaction should be covered and the results evaluated.

5.2

Understandings:

- The enthalpy change for a reaction that is carried out in a series of steps is equal to the sum of the enthalpy changes for the individual steps.

Applications and skills:

- Application of Hess's Law to calculate enthalpy changes.
- Calculation of ΔH reactions using ΔH_f data.
- Determination of the enthalpy change of a reaction that is the sum of multiple reactions with known enthalpy changes.

5.3

Understandings

- Bond-forming releases energy and bond-breaking requires energy.
- Average bond enthalpy is the energy needed to break one mol of a bond in a gaseous molecule averaged over similar compounds.

Applications and skills:

- Calculation of the enthalpy changes from known bond enthalpy values and comparison of these to experimentally measured values.
- Sketching and evaluation of potential energy profiles in determining whether reactants or products are more stable and if the reaction is exothermic or endothermic.
- Discussion of the bond strength in ozone relative to oxygen in its importance to the atmosphere.

Unit 15

15.1

Understandings:

- Representative equations (eg $M^+(g)$ $M^+(aq)$) can be used for enthalpy/energy of hydration, ionization, atomization, electron affinity, lattice, covalent bond and solution.
- Enthalpy of solution, hydration enthalpy and lattice enthalpy are related in an energy cycle.

Applications and skills:

- Construction of Born-Haber cycles for group 1 and 2 oxides and chlorides.
- Construction of energy cycles from hydration, lattice and solution enthalpy. For example dissolution of solid NaOH or NH_4Cl in water.

				<ul style="list-style-type: none"> •Calculation of enthalpy changes from Born-Haber or dissolution energy cycles. •Relate size and charge of ions to lattice and hydration enthalpies. •Perform lab experiments which could include single replacement reactions in aqueous solutions. <p>15.2 Understandings:</p> <ul style="list-style-type: none"> •Entropy (S) refers to the distribution of available energy among the particles. •The more ways the energy can be distributed the higher the entropy. •Gibbs free energy (G) relates the energy that can be obtained from a chemical reaction to the change in enthalpy (ΔH), change in entropy (ΔS), and absolute temperature (T). •Entropy of gas>liquid>solid under same conditions. <p>Applications and skills:</p> <ul style="list-style-type: none"> •Prediction of whether a change will result in an increase or decrease in entropy by considering the states of the reactants and products. •Calculation of entropy changes (ΔS) from given standard entropy values (S°). •Application of $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ in predicting spontaneity and calculation of various conditions of enthalpy and temperature that will affect this. 		
6. 2 weeks	Topic 6 Kinetics Topic 16 Kinetics HL only	<p>Social skills: group presentations on the different factors affecting rate Self-management skills Research skills</p> <p>Inquiry: Conceptual understanding Local and global contexts Teamwork and collaboration Differentiated Informed by assessment</p>	<p>Unit 6 6.1 Understandings:</p> <ul style="list-style-type: none"> •Species react as a result of collisions of sufficient energy and proper orientation. •The rate of reaction is expressed as the change in concentration of a particular reactant/product per unit time. • Concentration changes in a reaction can be followed indirectly by monitoring changes in mass, volume and colour. • Activation energy (E_a) is the minimum energy that colliding molecules need in order to have successful collisions leading to a reaction. • By decreasing E_a, a catalyst increases the rate of a chemical reaction, without itself being permanently chemically changed. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Description of the kinetic theory in terms of the movement of particles whose average kinetic energy is proportional to temperature in Kelvin. • Analysis of graphical and numerical data from rate experiments. • Explanation of the effects of temperature, pressure/concentration and particle size on rate of reaction. 	<p>“Note that the balanced equation of a reaction gives us no information about its rate. We can obtain this information only from experimental (empirical) data. Is there a fundamental difference between knowledge claims based on conclusions from theoretical considerations and those based on experimental data?”</p> <p>Set starter task: display a balanced equation and ask them to figure out the rate. Ask students to list features of experimental and theoretical data.</p>	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments	
16.1 1 week	Integrated with 11.2 SL and HL					
11.2 1 week						

				<ul style="list-style-type: none"> • Construction of Maxwell–Boltzmann energy distribution curves to account for the probability of successful collisions and factors affecting these, including the effect of a catalyst. • Investigation of rates of reaction experimentally and evaluation of the results. • Sketching and explanation of energy profiles with and without catalysts. <p>Unit 11 11.2 Understandings:</p> <ul style="list-style-type: none"> • Graphical techniques are an effective means of communicating the effect of an independent variable on a dependent variable, and can lead to determination of physical quantities. • Sketched graphs have labelled but unscaled axes, and are used to show qualitative trends, such as variables that are proportional or inversely proportional. • Drawn graphs have labelled and scaled axes, and are used in quantitative measurements. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Drawing graphs of experimental results including the correct choice of axes and scale. • Interpretation of graphs in terms of the relationships of dependent and independent variables. • Production and interpretation of best-fit lines or curves through data points, including an assessment of when it can and cannot be considered as a linear function. • Calculation of quantities from graphs by measuring slope (gradient) and intercept, including appropriate units. 		
12	9. 2 weeks 19. 1.5 weeks	Topic 9 Redox Topic 19 Redox HL only	<p>Inquiry: students will deduce the identity of a mystery compound using redox titration.</p> <p>Inquiry: students will deduce a metal activity series through experimenting into the possibility of single displacement reactions (using an online simulation or in the lab).</p> <p>Self-management: students will be asked to review the unit's understandings, applications, and skills, identify areas of confidence and challenge and take action to address areas of challenge in preparation for the end of year exam.</p>	<p>Unit 9 9.1 Understandings:</p> <ul style="list-style-type: none"> • Oxidation and reduction can be considered in terms of oxygen gain/hydrogen loss, electron transfer or change in oxidation number. • An oxidizing agent is reduced and a reducing agent is oxidized. • Variable oxidation numbers exist for transition metals and for most main-group non-metals. • The activity series ranks metals according to the ease with which they undergo oxidation. • The Winkler Method can be used to measure biochemical oxygen demand (BOD), used as a measure of the degree of pollution in a water sample. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of the oxidation states of an atom in an ion or a 	What ways of knowing can we use distinguish between the charge on an ion and the oxidation state?	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments

				<p>compound.</p> <ul style="list-style-type: none"> • Deduction of the name of a transition metal compound from a given formula, applying oxidation numbers represented by Roman numerals. • Identification of the species oxidized and reduced and the oxidizing and reducing agents, in redox reactions. • Deduction of redox reactions using half-equations in acidic or neutral solutions. • Deduction of the feasibility of a redox reaction from the activity series or reaction data. • Solution of a range of redox titration problems. • Application of the Winkler Method to calculate BOD. <p>9.2 Understandings: Voltaic (Galvanic) cells:</p> <ul style="list-style-type: none"> • Voltaic cells convert energy from spontaneous, exothermic chemical processes to electrical energy. • Oxidation occurs at the anode (negative electrode) and reduction occurs at the cathode (positive electrode) in a voltaic cell. <p>Electrolytic cells:</p> <ul style="list-style-type: none"> • Electrolytic cells convert electrical energy to chemical energy, by bringing about non-spontaneous processes. • Oxidation occurs at the anode (positive electrode) and reduction occurs at the cathode (negative electrode) in an electrolytic cell. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Construction and annotation of both types of electrochemical cells. • Explanation of how a redox reaction is used to produce electricity in a voltaic cell and how current is conducted in an electrolytic cell. • Distinction between electron and ion flow in both electrochemical cells. • Performance of laboratory experiments involving a typical voltaic cell using two metal/metal-ion half-cells. • Deduction of the products of the electrolysis of a molten salt. <p>Unit 19 19.1 Understandings: A voltaic cell generates an electromotive force (EMF) resulting in the movement of electrons from the anode (negative electrode) to the cathode (positive electrode) via the external circuit. The EMF is termed the cell potential (E^\ominus).</p> <ul style="list-style-type: none"> • The standard hydrogen electrode (SHE) consists of an inert platinum electrode in contact with 1 mol dm⁻³ hydrogen ion and hydrogen gas at 100 kPa and 298 K. The standard 		
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				<p>electrode potential (E°) is the potential (voltage) of the reduction half-equation under standard conditions measured relative to the SHE. Solute concentration is 1 mol dm^{-3} or 100 kPa for gases. E° of the SHE is 0 V.</p> <ul style="list-style-type: none"> • When aqueous solutions are electrolysed, water can be oxidized to oxygen at the anode and reduced to hydrogen at the cathode. • $\Delta G^\circ = -nFE^\circ$ When E° is positive, G° is negative indicative of a spontaneous process. When E° is negative, G° is positive indicative of a non-spontaneous process. When E° is 0, then G° is 0. • Current, duration of electrolysis and charge on the ion affect the amount of product formed at the electrodes during electrolysis. • Electroplating involves the electrolytic coating of an object with a metallic thin layer. <p>Applications and skills: Calculation of cell potentials using standard electrode potentials.</p> <ul style="list-style-type: none"> • Prediction of whether a reaction is spontaneous or not using E° values. • Determination of standard free-energy changes (ΔG°) using standard electrode potentials. • Explanation of the products formed during the electrolysis of aqueous solutions. • Perform lab experiments that could include single replacement reactions in aqueous solutions. • Determination of the relative amounts of products formed during electrolytic processes. • Explanation of the process of electroplating. 		
12	7. 1 week 17. 1 week	Topic 7. Equilibrium Topic 17. Equilibrium (HL Only)	<p>Every lesson and out of class assignment will incorporate multiple of the following skills/approaches:</p> <p>Student: Thinking Skills-Learn how to analyse, evaluate, discuss, and make connections Communication skills-Expressing judgements and views, writing succinct responses, and individual as well as group reports. Social skills-Students work in groups every class in a variety of situations. Full participation, listening skills, and social interactions are emphasized.</p>	<p>Unit 7 7.1 Understandings:</p> <ul style="list-style-type: none"> • A state of equilibrium is reached in a closed system when the rates of the forward and reverse reactions are equal. • The equilibrium law describes how the equilibrium constant (K_c) can be determined for a particular chemical reaction. • The magnitude of the equilibrium constant indicates the extent of a reaction at equilibrium and is temperature dependent. • The reaction quotient (Q) measures the relative amount of products and reactants present during a reaction at a particular point in time. Q is the equilibrium expression with non-equilibrium concentrations. The position of the equilibrium changes with changes in concentration, pressure, and temperature. 	The career of Fritz Haber coincided with the political upheavals of two world wars. He supervised the release of chlorine on the battlefield in World War I and worked on the production of explosives. How does the social context of scientific work affect the methods and findings of science? Should scientists be held morally responsible for the applications of their discoveries?	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments

			<p>Self-management skills-Being able to work independently, effectively, and in an organized manner</p> <p>Research skills-Looking up, evaluating, and using information from a variety of sources</p> <p>Teacher: Inquiry-Allow students to learn and come to conclusions by using guided inquiry</p> <p>Emphasizing concepts-Encourage students to see the lessons as interconnected and part of a big picture. Connect current lessons to previous and future topics</p> <p>Differentiation-A variety of teaching strategies and approaches will be used.</p> <p>Development of independence-Challenging tasks and high expectations will be set.</p> <p>Assessment-A variety of assessment methods will be used and feedback will be given in a variety of ways.</p> <p>Self-assessment and assessment of peers is an essential assessment component.</p>	<ul style="list-style-type: none"> • A catalyst has no effect on the position of equilibrium or the equilibrium constant. <p>Applications and skills:</p> <ul style="list-style-type: none"> • The characteristics of chemical and physical systems in a state of equilibrium. • Deduction of the equilibrium constant expression (K_c) from an equation for a homogeneous reaction. • Determination of the relationship between different equilibrium constants (K_c) for the same reaction at the same temperature. • Application of Le Châtelier's principle to predict the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium and on the value of the equilibrium constant. <p>Unit 15 15.2 Applications and skills: •Relation of ΔG to position of equilibrium.</p> <p>Unit 17 17.1 Understandings:</p> <ul style="list-style-type: none"> • Le Châtelier's principle for changes in concentration can be explained by the equilibrium law. • The position of equilibrium corresponds to a maximum value of entropy and a minimum in the value of the Gibbs free energy. • The Gibbs free energy change of a reaction and the equilibrium constant can both be used to measure the position of an equilibrium reaction and are related by the equation, $\Delta G = -RT \ln K$. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Solution of homogeneous equilibrium problems using the expression for K_c. • Relationship between ΔG and the equilibrium constant. • Calculations using the equation $\Delta G = -RT \ln K$. 		
12	8. 1.5 weeks 18. 2.5 weeks	Topic 8. Acids and bases Topic 18. Acids and Bases (HL Only)	<p>Every lesson and out of class assignment will incorporate multiple of the following skills/approaches:</p> <p>Student: Thinking Skills-Learn how to analyse, evaluate, discuss, and making connections</p> <p>Communication skills-Expressing judgements and views, writing succinct responses, and individual as</p>	<p>8.1 Understandings:</p> <ul style="list-style-type: none"> • A Brønsted-Lowry acid is a proton/H^+ donor and a Brønsted-Lowry base is a proton/H^+ acceptor. • Amphiprotic species can act as both Brønsted-Lowry acids and bases. • A pair of species differing by a single proton is called a conjugate acid-base pair. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of the Brønsted-Lowry acid and base in a chemical reaction. 	<p>Chemistry makes use of the universal language of mathematics as a means of communication. Why is it important to have just one "scientific" language?</p> <p>International mindedness Acid-base theory has developed from the ideas of people from different</p>	<p>Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments</p>

			<p>well as group reports. Social skills-Students work in groups every class in a variety of situations. Full participation, listening skills, and social interactions are emphasized. Self-management skills-Being able to work independently, effectively, and in an organized manner Research skills-Looking up, evaluating, and using information from a variety of sources</p> <p>Teacher: Inquiry-Allow students to learn and come to conclusions by using guided inquiry Emphasizing concepts-Encourage students to see the lessons as interconnected and part of a big picture. Connect current lessons to previous and future topics Differentiation-A variety of teaching strategies and approaches will be used. Development of independence-Challenging tasks and high expectations will be set. Assessment-A variety of assessment methods will be used and feedback will be given in a variety of ways. Self-assessment and assessment of peers is an essential assessment component.</p>	<ul style="list-style-type: none"> • Deduction of the conjugate acid or conjugate base in a chemical reaction. <p>8.2 Understandings:</p> <ul style="list-style-type: none"> • Most acids have observable characteristic chemical reactions with reactive metals, metal oxides, metal hydroxides, hydrogen carbonates and carbonates. • Salt and water are produced in exothermic neutralization reactions. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Balancing chemical equations for the reaction of acids. • Identification of the acid and base needed to make different salts. • Candidates should have experience of acid-base titrations with different indicators. <p>8.3 Understandings:</p> <ul style="list-style-type: none"> • $\text{pH} = -\log[\text{H}^+(\text{aq})]$ and $[\text{H}^+] = 10^{-\text{pH}}$. • A change of one pH unit represents a 10-fold change in the hydrogen ion concentration $[\text{H}^+]$. • pH values distinguish between acidic, neutral and alkaline solutions. • The ionic product constant, $K_w = [\text{H}^+][\text{OH}^-] = 10^{-14}$ at 298 K. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Solving problems involving pH, $[\text{H}^+]$ and $[\text{OH}^-]$. • Students should be familiar with the use of a pH meter and universal indicator. <p>8.4 Understandings:</p> <ul style="list-style-type: none"> • Strong and weak acids and bases differ in the extent of ionization. • Strong acids and bases of equal concentrations have higher conductivities than weak acids and bases. • A strong acid is a good proton donor and has a weak conjugate base. • A strong base is a good proton acceptor and has a weak conjugate acid. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Distinction between strong and weak acids and bases in terms of the rates of their reactions with metals, metal oxides, metal hydroxides, metal hydrogen carbonates and metal carbonates and their electrical conductivities for solutions of equal concentrations. <p>8.5</p>	<p>parts</p> <p>of the world through both collaboration and competition. (Consideration of the history of the development of acids and bases: Lavoisier (1777), The Arrhenius Theory, The Brønsted-Lowry Theory, Lewis Theory)</p> <p>TOK unit 18 only In what ways is the Lewis acid/base theory superior to the Brønsted-Lowry theory? (The same phenomenon can sometimes be explored from different perspectives, and explained by different theories. For example, do we judge competing theories by their universality, simplicity or elegance?)</p>	
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Understandings:

- Rain is naturally acidic because of dissolved CO_2 and has a pH of 5.6. Acid deposition has a pH below 5.6.
- Acid deposition is formed when nitrogen or sulfur oxides dissolve in water to form HNO_3 , HNO_2 , H_2SO_4 and H_2SO_3 .
- Sources of the oxides of sulfur and nitrogen and the effects of acid deposition should be covered.

Applications and skills:

- Balancing the equations that describe the combustion of sulfur and nitrogen to their oxides and the subsequent formation of H_2SO_3 , H_2SO_4 , HNO_2 and HNO_3 .
- Distinction between the pre-combustion and post-combustion methods of reducing sulfur oxides emissions.
- Deduction of acid deposition equations for acid deposition with reactive metals and carbonates.

Unit 18

18.1

Understandings:

- A Lewis acid is a lone pair acceptor and a Lewis base is a lone pair donor.
- When a Lewis base reacts with a Lewis acid a coordinate bond is formed.
- A nucleophile is a Lewis base and an electrophile is a Lewis acid.

Applications and skills:

- Application of Lewis' acid–base theory to inorganic and organic chemistry to identify the role of the reacting species.

18.2

Understandings:

- The expression for the dissociation constant of a weak acid (K_a) and a weak base (K_b).
- For a conjugate acid base pair, $K_a \times K_b = K_w$.
- The relationship between K_a and $\text{p}K_a$ is ($\text{p}K_a = -\log K_a$), and between K_b and $\text{p}K_b$ is ($\text{p}K_b = -\log K_b$).

Applications and skills:

- Solution of problems involving $[\text{H}^+ (\text{aq})]$, $[\text{OH}^- (\text{aq})]$, pH, pOH, K_a , $\text{p}K_a$, K_b and $\text{p}K_b$.
- Discussion of the relative strengths of acids and bases using values of K_a , $\text{p}K_a$, K_b and $\text{p}K_b$.

18.3

Understandings:

- The characteristics of the pH curves produced by the different combinations of strong and weak acids and bases.
- An acid–base indicator is a weak acid or a weak base where the components of the conjugate acid–base pair have different colours.

				<ul style="list-style-type: none"> The relationship between the pH range of an acid–base indicator, which is a weak acid, and its pK_a value. The buffer region on the pH curve represents the region where small additions of acid or base result in little or no change in pH. The composition and action of a buffer solution. <p>Applications and skills:</p> <ul style="list-style-type: none"> The general shapes of graphs of pH against volume for titrations involving strong and weak acids and bases with an explanation of their important features. Selection of an appropriate indicator for a titration, given the equivalence point of the titration and the end point of the indicator. While the nature of the acid–base buffer always remains the same, buffer solutions can be prepared by either mixing a weak acid/base with a solution of a salt containing its conjugate, or by partial neutralization of a weak acid/base with a strong acid/base. Prediction of the relative pH of aqueous salt solutions formed by the different combinations of strong and weak acid and base. 		
12	3. 1.5 weeks 13. 1 week 13 PSOW 1 hour	Topic 3. Periodicity Topic 13. The periodic Table-the transition metals (HL Only)	Every lesson and out of class assignment will incorporate multiple of the following skills/approaches: Student: Thinking Skills-Learn how to analyse, evaluate, discuss, and making connections Communication skills-Expressing judgements and views, writing succinct responses, and individual as well as group reports. Social skills-Students work in groups every class in a variety of situations. Full participation, listening skills, and social interactions are emphasized. Self-management skills-Being able to work independently, effectively, and in an organized manner Research skills-Looking up, evaluating, and using information from a variety of sources Teacher: Inquiry-Allow students to learn and come to conclusions by using guided inquiry	<p>3.1 Understandings:</p> <ul style="list-style-type: none"> The periodic table is arranged into four blocks associated with the four sublevels— s, p, d, and f. The periodic table consists of groups (vertical columns) and periods (horizontal rows). The period number (n) is the outer energy level that is occupied by electrons. The number of the principal energy level and the number of the valence electrons in an atom can be deduced from its position on the periodic table. The periodic table shows the positions of metals, non-metals and metalloids. <p>Applications and skills:</p> <ul style="list-style-type: none"> Deduction of the electron configuration of an atom from the element's position on the periodic table, and vice versa. <p>3.2 Understandings:</p> <ul style="list-style-type: none"> Vertical and horizontal trends in the periodic table exist for atomic radius, ionic radius, ionization energy, electron affinity and electronegativity. Trends in metallic and non-metallic behaviour are due to the trends above. Oxides change from basic through amphoteric to acidic across a period. <p>Applications and skills:</p>	The medical symbols for female and male originate from the alchemical symbols for copper and iron. What role has the pseudoscience of alchemy played in the development of modern science?	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments

			<p>Emphasizing concepts-Encourage students to see the lessons as interconnected and part of a big picture. Connect current lessons to previous and future topics Differentiation-A variety of teaching strategies and approaches will be used. Development of independence-Challenging tasks and high expectations will be set. Assessment-A variety of assessment methods will be used and feedback will be given in a variety of ways. Self-assessment and assessment of peers is an essential assessment component.</p>	<ul style="list-style-type: none"> • Prediction and explanation of the metallic and non-metallic behaviour of an element based on its position in the periodic table. • Discussion of the similarities and differences in the properties of elements in the same group, with reference to alkali metals (group 1) and halogens (group 17). • Construction of equations to explain the pH changes for reactions of Na_2O, MgO, P_4O_{10}, and the oxides of nitrogen and sulfur with water. <p>13.1 Understandings:</p> <ul style="list-style-type: none"> • Transition elements have variable oxidation states, form complex ions with ligands, have coloured compounds, and display catalytic and magnetic properties. • Zn is not considered to be a transition element as it does not form ions with incomplete d-orbitals. • Transition elements show an oxidation state of +2 when the s-electrons are removed. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Explanation of the ability of transition metals to form variable oxidation states from successive ionization energies. • Explanation of the nature of the coordinate bond within a complex ion. • Deduction of the total charge given the formula of the ion and ligands present. • Explanation of the magnetic properties in transition metals in terms of unpaired electrons. <p>13.2 Understandings:</p> <ul style="list-style-type: none"> • The d sub-level splits into two sets of orbitals of different energy in a complex ion. • Complexes of d-block elements are coloured, as light is absorbed when an electron is excited between the d-orbitals. • The colour absorbed is complementary to the colour observed. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Explanation of the effect of the identity of the metal ion, the oxidation number of the metal and the identity of the ligand on the colour of transition metal ion complexes. • Explanation of the effect of different ligands on the splitting of the d-orbitals in transition metal complexes and colour observed using the spectrochemical series. <p>PSOW: Students will perform substitution reactions to predict and explain the colour of transition metal ion complexes</p>		
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12	16. 1.5 weeks	Topic 16. Chemical Kinetics (HL Only)	<p>Every lesson and out of class assignment will incorporate multiple of the following skills/approaches:</p> <p>Student: Thinking Skills-Learn how to analyse, evaluate, discuss, and making connections Communication skills-Expressing judgements and views, writing succinct responses, and individual as well as group reports. Social skills-Students work in groups every class in a variety of situations. Full participation, listening skills, and social interactions are emphasized. Self-management skills-Being able to work independently, effectively, and in an organized manner Research skills-Looking up, evaluating, and using information from a variety of sources</p> <p>Teacher: Inquiry-Allow students to learn and come to conclusions by using guided inquiry Emphasizing concepts-Encourage students to see the lessons as interconnected and part of a big picture. Connect current lessons to previous and future topics Differentiation-A variety of teaching strategies and approaches will be used. Development of independence-Challenging tasks and high expectations will be set. Assessment-A variety of assessment methods will be used and feedback will be given in a variety of ways. Self-assessment and assessment of peers is an essential assessment component.</p>	<p>16.2 Understandings:</p> <ul style="list-style-type: none"> • The Arrhenius equation uses the temperature dependence of the rate constant to determine the activation energy. • A graph of $1/T$ against $\ln k$ is a linear plot with gradient $-E_a/R$ and intercept, $\ln A$. • The frequency factor (or pre-exponential factor) (A) takes into account the frequency of collisions with proper orientations. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Analysing graphical representation of the Arrhenius equation in its linear form • Describing the relationships between temperature and rate constant; frequency factor and complexity of molecules colliding. • Determining and evaluating values of activation energy and frequency factors from data. 		Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments
12	10. 3 weeks 16.	Topic 10. Organic Chemistry Topic 20. Organic Chemistry	Communication Students will learn about the	<p>10.1 Understandings:</p> <ul style="list-style-type: none"> • A homologous series is a series of compounds of the same family, with the same general formula, which differ from each 	Kekulé claimed that the inspiration for the cyclic structure of benzene came from a dream. What role do	Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments

	<p>1 week 20. 3 weeks</p>	<p>(HL Only)</p>	<p>importance of the nomenclature used for organic compounds, developing their skills in communication using scientific conventions, and also leaning how language can classify and bring order to systems.</p> <p>Self-management Students will be assigned various sections of this unit as self study and, though students will be guided and given class time, students will be asked to plan their time and reflect on time management.</p>	<p>other by a common structural unit.</p> <ul style="list-style-type: none"> • Structural formulas can be represented in full and condensed format. • Structural isomers are compounds with the same molecular formula but different arrangements of atoms. • Functional groups are the reactive parts of molecules. • Saturated compounds contain single bonds only and unsaturated compounds contain double or triple bonds. • Benzene is an aromatic, unsaturated hydrocarbon. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Explanation of the trends in boiling points of members of a homologous series. • Distinction between empirical, molecular and structural formulas. • Identification of different classes: alkanes, alkenes, alkynes, halogenoalkanes, alcohols, ethers, aldehydes, ketones, esters, carboxylic acids, amines, amides, nitriles and arenes. • Identification of typical functional groups in molecules eg phenyl, hydroxyl, carbonyl, carboxyl, carboxamide, aldehyde, ester, ether, amine, nitrile, alkyl, alkenyl and alkynyl. • Construction of 3-D models (real or virtual) of organic molecules. • Application of IUPAC rules in the nomenclature of straight-chain and branched-chain isomers. • Identification of primary, secondary and tertiary carbon atoms in halogenoalkanes and alcohols and primary, secondary and tertiary nitrogen atoms in amines. • Discussion of the structure of benzene using physical and chemical evidence. <p>10.2 Understandings:</p> <p><i>Alkanes:</i></p> <ul style="list-style-type: none"> • Alkanes have low reactivity and undergo free-radical substitution reactions. <p><i>Alkenes:</i></p> <ul style="list-style-type: none"> • Alkenes are more reactive than alkanes and undergo addition reactions. Bromine water can be used to distinguish between alkenes and alkanes. <p><i>Alcohols:</i></p> <ul style="list-style-type: none"> • Alcohols undergo nucleophilic substitution reactions with acids (also called esterification or condensation) and some undergo oxidation reactions. <p><i>Halogenoalkanes:</i></p> <ul style="list-style-type: none"> • Halogenoalkanes are more reactive than alkanes. They can undergo (nucleophilic) substitution reactions. A nucleophile is an electron-rich species containing a lone pair that it donates to an electron-deficient carbon. 	<p>the less analytical ways of knowledge play in the acquisition of scientific knowledge?</p>	
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Polymers:

- Addition polymers consist of a wide range of monomers and form the basis of the plastics industry.

Benzene:

- Benzene does not readily undergo addition reactions but does undergo electrophilic substitution reactions.

Applications and skills:

Alkanes:

- Writing equations for the complete and incomplete combustion of hydrocarbons.
- Explanation of the reaction of methane and ethane with halogens in terms of a free-radical substitution mechanism involving photochemical homolytic fission.

Alkenes:

- Writing equations for the reactions of alkenes with hydrogen and halogens and of symmetrical alkenes with hydrogen halides and water.
- Outline of the addition polymerization of alkenes.
- Relationship between the structure of the monomer to the polymer and repeating unit.

Alcohols:

- Writing equations for the complete combustion of alcohols.
- Writing equations for the oxidation reactions of primary and secondary alcohols (using acidified potassium dichromate(VI) or potassium manganate(VII) as oxidizing agents).

Explanation of distillation and reflux in the isolation of the aldehyde and carboxylic acid products.

- Writing the equation for the condensation reaction of an alcohol with a carboxylic acid, in the presence of a catalyst (eg concentrated sulfuric acid) to form an ester.

Halogenoalkanes:

- Writing the equation for the substitution reactions of halogenoalkanes with aqueous sodium hydroxide.

Unit 16

16.1

Understandings:

- Reactions may occur by more than one step and the slowest step determines the rate of reaction (rate determining step/RDS).
- The molecularity of an elementary step is the number of reactant particles taking part in that step.
- The order of a reaction can be either integer or fractional in nature. The order of a reaction can describe, with respect to a reactant, the number of particles taking part in the rate-determining step.
- Catalysts alter a reaction mechanism, introducing a step with lower activation energy.

Applications and skills:

• Evaluation of proposed reaction mechanisms to be consistent with kinetic and stoichiometric data.

Unit 20

20.1

Understanding:

Nucleophilic Substitution Reactions:

- S_N1 represents a nucleophilic unimolecular substitution reaction and S_N2 represents a nucleophilic bimolecular substitution reaction. S_N1 involves a carbocation intermediate. S_N2 involves a concerted reaction with a transition state.
- For tertiary halogenoalkanes the predominant mechanism is S_N1 and for primary halogenoalkanes it is S_N2 . Both mechanisms occur for secondary halogenoalkanes.
- The rate determining step (slow step) in an S_N1 reaction depends only on the concentration of the halogenoalkane, rate = $k[\text{halogenoalkane}]$. For S_N2 , rate = $k[\text{halogenoalkane}][\text{nucleophile}]$. S_N2 is stereospecific with an inversion of configuration at the carbon.

• S_N2 reactions are best conducted using aprotic, non-polar solvents and S_N1 reactions are best conducted using protic, polar solvents.

Electrophilic Addition Reactions:

- An electrophile is an electron-deficient species that can accept electron pairs from a nucleophile. Electrophiles are Lewis acids.
- Markovnikov's rule can be applied to predict the major product in electrophilic addition reactions of unsymmetrical alkenes with hydrogen halides and interhalogens. The formation of the major product can be explained in terms of the relative stability of possible carbocations in the reaction mechanism.

Electrophilic Substitution Reactions:

- Benzene is the simplest aromatic hydrocarbon compound (or arene) and has a delocalized structure of π bonds around its ring. Each carbon to carbon bond has a bond order of 1.5. Benzene is susceptible to attack by electrophiles.

Reduction Reactions:

- Carboxylic acids can be reduced to primary alcohols (via the aldehyde). Ketones can be reduced to secondary alcohols. Typical reducing agents are lithium aluminium hydride (used to reduce carboxylic acids) and sodium borohydride.

Applications and skills:

Nucleophilic Substitution Reactions:

- Explanation of why hydroxide is a better nucleophile than water.
- Deduction of the mechanism of the nucleophilic substitution reactions of halogenoalkanes with aqueous sodium hydroxide in terms of S_N1 and S_N2 mechanisms. Explanation of how the

				<p>rate depends on the identity of the halogen (ie the leaving group), whether the halogenoalkane is primary, secondary or tertiary and the choice of solvent.</p> <ul style="list-style-type: none"> • Outline of the difference between protic and aprotic solvents. <p>Electrophilic Addition Reactions:</p> <ul style="list-style-type: none"> • Deduction of the mechanism of the electrophilic addition reactions of alkenes with halogens/interhalogens and hydrogen halides. <p>Electrophilic Substitution Reactions:</p> <ul style="list-style-type: none"> • Deduction of the mechanism of the nitration (electrophilic substitution) reaction of benzene (using a mixture of concentrated nitric acid and sulfuric acid). <p>Reduction Reactions:</p> <ul style="list-style-type: none"> • Writing reduction reactions of carbonyl containing compounds: aldehydes and ketones to primary and secondary alcohols and carboxylic acids to aldehydes, using suitable reducing agents. • Conversion of nitrobenzene to phenylamine via a two-stage reaction. <p>20.2</p> <p>Understandings:</p> <ul style="list-style-type: none"> • The synthesis of an organic compound stems from a readily available starting material via a series of discrete steps. Functional group interconversions are the basis of such synthetic routes. • Retro-synthesis of organic compounds. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Deduction of multi-step synthetic routes given starting reagents and the product(s). <p>20.3</p> <p>Understandings:</p> <ul style="list-style-type: none"> • Stereoisomers are subdivided into two classes—conformational isomers, which interconvert by rotation about a σ bond and configurational isomers that interconvert only by breaking and reforming a bond. Configurational isomers are further subdivided into cis-trans and E/Z isomers and optical isomers. • Cis-trans isomers can occur in alkenes or cycloalkanes (or heteroanalogues) and differ in the positions of atoms (or groups) relative to a reference plane. According to IUPAC, E/Z isomers refer to alkenes of the form $R_1R_2C=CR_3R_4$ ($R_1 \neq R_2$, $R_3 \neq R_4$) where neither R_1 nor R_2 need be different from R_3 or R_4. • A chiral carbon is a carbon joined to four different atoms or groups. • An optically active compound can rotate the plane of polarized light as it passes through a solution of the 		
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				<p>compound. Optical isomers are enantiomers. Enantiomers are non-superimposable mirror images of each other. Diastereomers are not mirror images of each other.</p> <ul style="list-style-type: none"> • A racemic mixture (or racemate) is a mixture of two enantiomers in equal amounts and is optically inactive. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Construction of 3-D models (real or virtual) of a wide range of stereoisomers. • Explanation of stereoisomerism in non-cyclic alkenes and C3 and C4 Cycloalkanes. • Comparison between the physical and chemical properties of enantiomers. • Description and explanation of optical isomers in simple organic molecules. • Distinction between optical isomers using a polarimeter. 		
12	<p>11. 1 week</p> <p>21. 0.5 week</p>	<p>Topic 11. Measurement and data processing</p> <p>Topic 21. Measurement and Analysis (HL Only)</p>	<p>Every lesson and out of class assignment will incorporate multiple of the following skills/approaches:</p> <p>Student:</p> <p>Thinking Skills-Learn how to analyse, evaluate, discuss, and making connections</p> <p>Communication skills-Expressing judgements and views, writing succinct responses, and individual as well as group reports.</p> <p>Social skills-Students work in groups every class in a variety of situations. Full participation, listening skills, and social interactions are emphasized.</p> <p>Self-management skills-Being able to work independently, effectively, and in an organized manner</p> <p>Research skills-Looking up, evaluating, and using information from a variety of sources</p> <p>Teacher:</p> <p>Inquiry-Allow students to learn and come to conclusions by using guided inquiry</p> <p>Emphasizing concepts-Encourage students to see the lessons as interconnected and part of a big picture. Connect current lessons to previous and future topics</p>	<p>Unit 11</p> <p>11.3</p> <p>Understandings:</p> <ul style="list-style-type: none"> • The degree of unsaturation or index of hydrogen deficiency (IHD) can be used to determine from a molecular formula the number of rings or multiple bonds in a molecule. • Mass spectrometry (MS), proton nuclear magnetic resonance spectroscopy (¹H NMR) and infrared spectroscopy (IR) are techniques that can be used to help identify compounds and to determine their structure. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Determination of the IHD from a molecular formula. • Deduction of information about the structural features of a compound from percentage composition data, MS, ¹H NMR or IR. <p>Unit 21</p> <p>21.1</p> <p>Understandings:</p> <ul style="list-style-type: none"> • Structural identification of compounds involves several different analytical techniques including IR, ¹H NMR and MS. • In a high resolution ¹H NMR spectrum, single peaks present in low resolution can split into further clusters of peaks. • The structural technique of single crystal X-ray crystallography can be used to identify the bond lengths and bond angles of crystalline compounds. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Explanation of the use of tetramethylsilane (TMS) as the reference standard. • Deduction of the structure of a compound given information from a range of analytical characterization techniques (X-ray crystallography, IR, ¹H NMR and MS). 	<p>TOK, NOS and International minded ness.</p> <p>Documentary on the discovery of different forms of matter.</p> <p>Reflection on:What is spectroscopy? What is its role in developing our understanding of matter? How does it show limitations of sense perception as a way of knowing?What evidence is there that Science is a collaborative endeavor?</p>	<p>Multiple quizzes</p> <p>Paper 1 and 2 tests</p> <p>Homework scores</p> <p>IA assessments</p>

			<p>Differentiation-A variety of teaching strategies and approaches will be used.</p> <p>Development of independence-Challenging tasks and high expectations will be set.</p> <p>Assessment-A variety of assessment methods will be used and feedback will be given in a variety of ways.</p> <p>Self-assessment and assessment of peers is an essential assessment component.</p>			
12	<p>Options C1-C5. 3 weeks</p> <p>Options C6-C8 2 weeks</p>	<p>Options C1-C5 Energy</p> <p>Options C6-C8 Energy (HL Only)</p>	<p>C5 will be assigned as self-study. Students will be required to share how they plan their time.</p>	<p>C1</p> <p>Understandings:</p> <ul style="list-style-type: none"> • A useful energy source releases energy at a reasonable rate and produces minimal pollution. • The quality of energy is degraded as heat is transferred to the surroundings. Energy and materials go from a concentrated into a dispersed form. The quantity of the energy available for doing work decreases. • Renewable energy sources are naturally replenished. Non-renewable energy sources are finite. • Energy density = energy released from fuel / volume of fuel consumed . • Specific energy = energy released from fuel / mass of fuel consumed. • The efficiency of an energy transfer = useful output energy / total input energy x 100%. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Discussion of the use of different sources of renewable and non-renewable energy. • Determination of the energy density and specific energy of a fuel from the enthalpies of combustion, densities and the molar mass of fuel. • Discussion of how the choice of fuel is influenced by its energy density or specific energy. • Determination of the efficiency of an energy transfer process from appropriate data. • Discussion of the advantages and disadvantages of the different energy sources in C.2 through to C.8. <p>C2</p> <p>Understandings:</p> <ul style="list-style-type: none"> • Fossil fuels were formed by the reduction of biological compounds that contain carbon, hydrogen, nitrogen, sulfur and oxygen. • Petroleum is a complex mixture of hydrocarbons that can be split into different component parts called fractions by 	<p>The use of nuclear energy carries risks as well as benefits. Is the public perception that nuclear power is dangerous well founded?</p>	<p>Multiple quizzes Paper 1 and 2 tests Homework scores IA assessments</p>

fractional distillation.

- Crude oil needs to be refined before use. The different fractions are separated by a physical process in fractional distillation.
- The tendency of a fuel to auto-ignite, which leads to “knocking” in a car engine, is related to molecular structure and measured by the octane number.
- The performance of hydrocarbons as fuels is improved by the cracking and catalytic reforming reactions.
- Coal gasification and liquefaction are chemical processes that convert coal to gaseous and liquid hydrocarbons.
- A carbon footprint is the total amount of greenhouse gases produced during human activities. It is generally expressed in equivalent tons of carbon dioxide.

Applications and skills:

- Discussion of the effect of chain length and chain branching on the octane number.
- Discussion of the reforming and cracking reactions of hydrocarbons and explanation how these processes improve the octane number.
- Deduction of equations for cracking and reforming reactions, coal gasification and liquefaction.
- Discussion of the advantages and disadvantages of the different fossil fuels.
- Identification of the various fractions of petroleum, their relative volatility and their uses.
- Calculations of the carbon dioxide added to the atmosphere, when different fuels burn and determination of carbon footprints for different activities.

C3

Understandings:

Nuclear fusion

- Light nuclei can undergo fusion reactions as this increases the binding energy per nucleon.
- Fusion reactions are a promising energy source as the fuel is inexpensive and abundant, and no radioactive waste is produced.
- Absorption spectra are used to analyse the composition of stars.

Nuclear fission

- Heavy nuclei can undergo fission reactions as this increases the binding energy per nucleon.
- ^{235}U undergoes a fission chain reaction:
 $\text{U-235} + n \rightarrow \text{U-236} \rightarrow \text{X} + \text{Y} + \text{neutrons}$.
- The critical mass is the mass of fuel needed for the reaction to be self-sustaining.
- ^{239}Pu , used as a fuel in “breeder reactors”, is produced from ^{238}U by neutron capture.

- Radioactive waste may contain isotopes with long and short half-lives.
- Half-life is the time it takes for half the number of atoms to decay.

Applications and skills:

Nuclear fusion

- Construction of nuclear equations for fusion reactions.
- Explanation of fusion reactions in terms of binding energy per nucleon.
- Explanation of the atomic absorption spectra of hydrogen and helium, including the relationships between the lines and electron transitions.

Nuclear fission

- Deduction of nuclear equations for fission reactions.
- Explanation of fission reactions in terms of binding energy per nucleon.
- Discussion of the storage and disposal of nuclear waste.
- Solution of radioactive decay problems involving integral numbers of half-lives.

C4

Understandings:

- Light can be absorbed by chlorophyll and other pigments with a conjugated electronic structure.
- Photosynthesis converts light energy into chemical energy:
 $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- Fermentation of glucose produces ethanol which can be used as a biofuel: $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$
- Energy content of vegetable oils is similar to that of diesel fuel but they are not used in internal combustion engines as they are too viscous.
- Transesterification between an ester and an alcohol with a strong acid or base catalyst produces a different ester:
 $\text{RCOOR}^1 + \text{R}^2\text{OH} \rightarrow \text{RCOOR}^2 + \text{R}^1\text{OH}$
- In the transesterification process, involving a reaction with an alcohol in the presence of a strong acid or base, the triglyceride vegetable oils are converted to a mixture mainly comprising of alkyl esters and glycerol, but with some fatty acids.
- Transesterification with ethanol or methanol produces oils with lower viscosity that can be used in diesel engines.

Applications and skills:

- Identification of features of the molecules that allow them to absorb visible light.
- Explanation of the reduced viscosity of esters produced with methanol and ethanol.
- Evaluation of the advantages and disadvantages of the use of biofuels.
- Deduction of equations for transesterification reactions.

C5

Understandings:

- Greenhouse gases allow the passage of incoming solar short wavelength radiation but absorb the longer wavelength radiation from the Earth. Some of the absorbed radiation is re-radiated back to Earth.
- There is a heterogeneous equilibrium between concentration of atmospheric carbon dioxide and aqueous carbon dioxide in the oceans.
- Greenhouse gases absorb IR radiation as there is a change in dipole moment as the bonds in the molecule stretch and bend.
- Particulates such as smoke and dust cause global dimming as they reflect sunlight, as do clouds.

Applications and skills:

- Explanation of the molecular mechanisms by which greenhouse gases absorb infrared radiation.
- Discussion of the evidence for the relationship between the increased concentration of gases and global warming.
- Discussion of the sources, relative abundance and effects of different greenhouse gases.
- Discussion of the different approaches to the control of carbon dioxide emissions.
- Discussion of pH changes in the ocean due to increased concentration of carbon dioxide in the atmosphere.

C6

Understandings:

- An electrochemical cell has internal resistance due to the finite time it takes for ions to diffuse. The maximum current of a cell is limited by its internal resistance.
- The voltage of a battery depends primarily on the nature of the materials used while the total work that can be obtained from it depends on their quantity.
- In a primary cell the electrochemical reaction is not reversible. Rechargeable cells involve redox reactions that can be reversed using electricity.
- A fuel cell can be used to convert chemical energy, contained in a fuel that is consumed, directly to electrical energy.
- Microbial fuel cells (MFCs) are a possible sustainable energy source using different carbohydrates or substrates present in waste waters as the fuel.
- The Nernst equation, can be used to calculate the potential of a half-cell in an electrochemical cell, under non-standard conditions.
- The electrodes in a concentration cell are the same but the concentration of the electrolyte solutions at the cathode and

anode are different.

Applications and skills:

- Distinction between fuel cells and primary cells.
- Deduction of half equations for the electrode reactions in a fuel cell.
- Comparison between fuel cells and rechargeable batteries.
- Discussion of the advantages of different types of cells in terms of size, mass and voltage.
- Solution of problems using the Nernst equation.
- Calculation of the thermodynamic efficiency ($\Delta G/\Delta H$) of a fuel cell.
- Explanation of the workings of rechargeable and fuel cells including diagrams and relevant half-equations.

C7

Understandings:

Nuclear fusion:

- The mass defect (Δm) is the difference between the mass of the nucleus and the sum of the masses of its individual nucleons.
- The nuclear binding energy (ΔE) is the energy required to separate a nucleus into protons and neutrons.

Nuclear fission:

- The energy produced in a fission reaction can be calculated from the mass difference between the products and reactants using the Einstein mass–energy equivalence relationship $E = mc^2$
- The different isotopes of uranium in uranium hexafluoride can be separated, using diffusion or centrifugation causing fuel enrichment.
- The effusion rate of a gas is inversely proportional to the square root of the molar mass (Graham's Law).
- Radioactive decay is kinetically a first order process with the half-life related to the decay constant.
- The dangers of nuclear energy are due to the ionizing nature of the radiation it produces which leads to the production of oxygen free radicals such as superoxide (O_2^-), and hydroxyl ($HO\cdot$). These free radicals can initiate chain reactions that can damage DNA and enzymes in living cells.

Applications and skills:

Nuclear fusion:

- Calculation of the mass defect and binding energy of a nucleus.
- Application of the Einstein mass–energy equivalence relationship, $E = mc^2$, to determine the energy produced in a fusion reaction.

Nuclear fission:

- Application of the Einstein mass–energy equivalence

				<p>relationship to determine the energy produced in a fission reaction.</p> <ul style="list-style-type: none"> • Discussion of the different properties of UO_2 and UF_6 in terms of bonding and structure. • Solution of problems involving radioactive half-life. • Explanation of the relationship between Graham's law of effusion and the kinetic theory. • Solution of problems on the relative rate of effusion using Graham's law. <p>C8</p> <p>Understandings:</p> <ul style="list-style-type: none"> • Molecules with longer conjugated systems absorb light of longer wavelength. • The electrical conductivity of a semiconductor increases with an increase in temperature whereas the conductivity of metals decreases. • The conductivity of silicon can be increased by doping to produce n-type and p-type semiconductors. • Solar energy can be converted to electricity in a photovoltaic cell. • DSSCs imitate the way in which plants harness solar energy. Electrons are "injected" from an excited molecule directly into the TiO_2 semiconductor. • The use of nanoparticles coated with light-absorbing dye increases the effective surface area and allows more light over a wider range of the visible spectrum to be absorbed. <p>Applications and skills:</p> <ul style="list-style-type: none"> • Relation between the degree of conjugation in the molecular structure and the wavelength of the light absorbed. • Explanation of the operation of the photovoltaic and dye-sensitized solar cell. • Explanation of how nanoparticles increase the efficiency of DSSCs. • Discussion of the advantages of the DSSC compared to the silicon-based 		
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NOTES for 19-20:

- Add in PSOW as go through. Also put the labs in the overview.
- ATL skills for G12 classes.
- Link the TOK connection to one the check boxes on MB
- Lab linked to option
- Inquiry Qs for unit 10/20 and option
- Unit 11 is integrated in this document. But not added to MB
- Collaboration skills not done MB
- As we teach, make sure there is a slide in the presentations that links to the TOK or international mindedness that we have selected.
- Durations and timings on MB
- Inquiry questions option

Question: should I be pasting essential ideas into essential understandings on MB, rather than the understandings that are then selected on the next page?