**Mearns Castle High School**

**National 5**

**Chemistry**



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**Learning Outcomes**

**Unit 1: Chemical Changes and Structure**

1. *Reaction Rates*

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|  | The factors affecting the rate of a reaction are concentration, temperature, surface area and presence of a catalyst.  |
|  | Reactions can be followed by measuring changes in concentration, mass and volume of reactants and products.  |
|  | The average rate of a reaction, or stage in a reaction, can be calculated from initial and final quantities and the time interval.  |
|  | Average rates of reaction over various time intervals during the reaction can be used to show that as a reaction progresses the rate of reaction decreases.  |

1. *Atomic Structure and Bonding*

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|  | **Atomic Structure** |
|  | The periodic table is arranged in groups (vertical columns) and periods (horizontal rows).  |
|  | Group 1 is the Alkali metals, group 7 is the Halogens and group 0 is the Noble Gases. The block between Groups 2 and 3 are called the Transition Metals |
|  | Every element has its own symbol and atomic number  |
|  | Every element is made up of very small particles called atoms |
|  | Atoms have a nucleus, which contains protons and neutrons, with electrons moving around the outside |
|  | The atomic number of an element gives the number of protons in its nucleus |
|  | Protons have a charge of one positive, electrons have a charge of one negative and neutrons are neutral (have no charge)  |
|  | An atom is neutral because the number of protons is equal to the number of electrons  |
|  | Protons and neutrons have a mass of 1 amu, electrons have a mass of (almost) zero |
|  | The mass number of an element is equal to the number of protons + the number of neutrons  |
|  | Isotopes are atoms of the same atomic number with different mass numbers. (Same number of protons but different number of neutrons) |
|  | Relative atomic mass is the average mass of the isotopes present taking into account their relative proportions.  |
|  | When there is an imbalance in the number of positive protons and electrons the particle is known as an ion.  |
|  | Ions are charged particles formed by the loss or gain of electrons from an atom, in order to achieve a stable electron arrangement.  |
|  | Nuclide notation is a short hand way of showing the number of subatomic particles in an atom or ion  |

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|  | **Bonding** |
|  | A diatomic molecule is one containing 2 atoms. The following elements exist as diatomic molecules:Hydrogen, nitrogen, oxygen, the halogens  |
|  | Non-metal atoms bond by sharing electrons. This is a covalent bond |
|  | A molecule is a group of atoms joined by covalent bonds |
|  | In a covalent bond, the shared pair of electrons is attracted to the nuclei of the two bonded atoms.  |
|  | More than one bond can be formed between atoms leading to double and triple covalent bonds  |
|  | Electron Sharing Diagrams can be used to show how electrons are shared in a covalent bond |
|  | Diagrams can show the shape of simple 2 element molecules. Shapes include linear, angular, trigonal pyramidal and tetrahedral. |
|  | Covalent substances can form either discrete molecular or giant network structures.  |
|  | Metals and non-metals bond with one another by transferring electrons. This is an ionic bond. |
|  | Ionic bonds are the electrostatic attraction between positive and negative ions.  |
|  | Ionic compounds form lattice structures of oppositely charged ions.  |
|  | **Properties**  |
|  | Covalent molecular substances have low melting and boiling points due to only weak forces of attraction between molecules being broken.  |
|  | Giant covalent network structures have very high melting and boiling points because the network of strong covalent bonds must be broken.  |
|  | Covalent substances cannot conduct electricity in any state as there are no charged particles free to move  |
|  | Ionic compounds have high melting and boiling points because strong ionic bonds must be broken in order to break down the lattice.  |
|  | Dissolving also breaks down the lattice structure.  |
|  | Ionic compounds conduct electricity, only when molten or in solution due to the breakdown of the lattice resulting in the ions being free to move.  |
|  | Experimental procedures are required to confirm the type of bonding present in a substance.  |

1. *Formulae and Reaction Quantities*

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|  | **Formulae** |
|  | Formulae can be written from prefixes mono-, di- , tri- etc.  |
|  | Formulae for simple 2 element compounds can be written from the group number  |
|  | Formulae can be written for compounds containing transition metals given a roman numeral  |
|  | Formula can be written for group ions using brackets |
|  | The chemical formula of a covalent molecular substance gives the number of atoms present in the molecule. The formula of a covalent network or ionic compound gives the simplest ratio of atoms/ions in the substance.  |
|  | Formula equations can be balanced to show the relative number of moles of reactant(s) and product(s) |
|  | State symbols can be used to show the physical state of substances in an equation. |
|  | **Moles** |
|  | The gram formula mass is defined as the mass of one mole of a substance.  |
|  | Using the chemical formula of any substance the gram formula mass can be calculated using relative formula masses of its constituent elements.  |
|  | The number of moles can be calculated from the mass of a substance and vice versa.  |
|  | The mass of a reactant or product can be calculated using a balanced equation.  |
|  | The concentration of a solution is expressed in mol l-1.  |
|  | The number of moles of solute, volume and concentration of a solution can be calculated from the other two variables.  |

1. *Acids and Bases*

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|  | Acids have a pH of less than 7, neutral solutions have a pH of 7, Alkaline solutions have a pH greater than 7 |
|  | Non-metal oxides which dissolve in water produce acid solutions. Metal oxides which dissolve in water produce alkaline solutions (metal hydroxides)Ammonia dissolves in water to produce an alkali.  |
|  | A very small proportion of water molecules will dissociate into an equal number of hydrogen and hydroxide ions.  |
|  | The pH is a measure of the hydrogen ion concentration. A neutral solution has an equal concentration of hydrogen and hydroxide ions. A solution with a greater concentration of hydrogen ions than hydroxide ions is an acid. When the reverse is true the solution is known as an alkali.  |
|  | The effect of dilution of an acid or alkali with water is related to the concentrations of hydrogen and hydroxide ions  |
|  | Neutralisation is the reaction of acids with bases. The pH moves towards 7.  |
|  | Metal oxides, metal hydroxides and metal carbonates are examples of bases.  |
|  | A salt and water are always formed in neutralisation reaction. When the base used is a metal carbonate, carbon dioxide is also formed.  |
|  | The name of the salt formed can be determined from the name of the acid and base.  |
|  | Insoluble salts can be made by a precipitation reaction  |
|  | For the neutralisation reactions of acids with alkalis or metal carbonates, the reacting species is determined by omission of spectator ions.  |
|  | Titration is an analytical technique used to determine the accurate volumes involved in chemical reactions such as neutralisation. An indicator is used to show the end-point of the reaction.  |
|  | The concentration of acids/alkalis can be calculated from the results of volumetric titrations.  |

**Unit 2: Nature’s Chemistry**

1. *Homologous Series*

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|  | A hydrocarbon is a compound containing hydrogen and carbon only |
|  | The alkanes are an homologous series of hydrocarbons |
|  | The general formula for the alkanes is CnH2n+2.  |
|  | An alkane can be identified from the ‘-ane’ ending.  |
|  | Straight-chain alkanes can be named from molecular formulae, shortened and full structural formulae (only C1 to C8)  |
|  | Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of straight-chain alkanes (only C1 to C8).  |
|  | Branched-chain alkanes can be systematically named from shortened and full structural formulae (only C4 to C8).  |
|  | Branched chain alkanes are very useful as fuels.  |
|  | The alkenes are another homologous series of hydrocarbons  |
|  | The general formula for the alkenes is CnH2n  |
|  | An alkene can be identified from the carbon to carbon double bond and the ‘-ene’ ending.  |
|  | Straight-chain alkenes can be named, incorporating the position of the double bond, from shortened and full structural formulae (only C2 to C8).  |
|  | Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of alkenes (only C2 to C8).  |
|  | Branched-chain alkenes can be systematically named from shortened and full structural formulae (only C4 to C8). |
|  | Branched chain alkenes are used in the manufacture of plastics.  |
|  | The cycloalkanes are a third homologous series of hydrocarbons |
|  | The general formula for the cycloalkanes is CnH2n.  |
|  | Cycloalkanes can be named from molecular formulae, shortened and full structural formulae (only C3 to C8) |
|  | Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of cycloalkanes (only C3 to C8).  |
|  | Saturated hydrocarbons contain only single carbon to carbon bonds |
|  | An unsaturated hydrocarbon is one which contains at least one carbon to carbon double or triple bond.  |
|  | Alkenes are described as unsaturated hydrocarbons and can undergo addition reactions that convert them into alkanes. |
|  | Alkenes can also undergo addition reactions with halogens |
|  | Molecular and structural equations can be given to represent these addition reactions  |
|  | The test for unsaturation is addition of a few drops of bromine solution which will quickly be decolourised |
|  | A homologous series is a set of compounds with the same general formula and similar chemical properties.  |
|  | Isomers are compounds with the same molecular formula but different structural formulae.  |
|  | Isomers can be drawn for given molecular formulae, shortened and full structural formulae.  |
|  | Isomers have different physical properties. These properties can be explained in terms of the intermolecular forces involved.  |

1. *Everyday Consumer Products*

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|  | **Alcohols** |
|  | An alcohol is identified from the hydroxyl (–OH) group and the ending ‘-ol’.  |
|  | Straight-chain alcohols can be named, incorporating the position of the hydroxyl group, from shortened and full structural formulae (only C1 to C8).  |
|  | Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of straight-chain alkanols (only C1 to C8).  |
|  | Alcohols are highly flammable and burn with a clean flame.  |
|  | The physical properties of alcohols (melting & boiling point and solubility in water) can be explained in terms of intermolecular forces |
|  | Uses of alcohol include: the use of ethanol in alcoholic drinks, as effective solvents, and as a renewable fuel.  |
|  | Carboxylic Acids  |
|  | Carboxylic acids can be identified by the carboxyl ending, the COOH functional group and the ‘-oic’ name ending.  |
|  | Straight-chain carboxylic acids can be named from shortened and full structural formulae (only C1 to C8 ).  |
|  | Molecular formulae can be written and shortened and full structural formulae can be drawn, given the name of straight-chain carboxylic acids (only C1 to C8).  |
|  | Carboxylic acids have a pH of less than 7, and react as other acids with metals, metal oxides and carbonates  |
|  | Physical properties of carboxylic acids (melting & boiling point and solubility in water) can be explained in terms of intermolecular forces |
|  | Vinegar is a solution of ethanoic acid.  |
|  | Vinegar is used in household cleaning products designed to remove lime scale and as a preservative in the food industry.  |
|  | **Esters** |
|  | An ester can be made by reacting a carboxylic acid and an alcohol.  |
|  | Some uses of esters are in food flavouring, industrial solvents, fragrances and materials.  |

1. *Energy From Fuels*

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|  | Alkanes and alcohols can be burned to release energy and as such are described as fuels.  |
|  | Burning (combustion) is the reaction of a substance with oxygen  |
|  | When hydrocarbons/alcohols burn in a plentiful supply of oxygen, the products are carbon dioxide and water.  |
|  | When a substance is combusted the reaction can be represented using a balanced formulae equation.  |
|  | The quantities of reactants and products in these reactions can be calculated.  |
|  | Reactions which give out heat (such as combustion) are described as exothermic.  |
|  | Reactions which take in heat are described as endothermic.  |
|  | Different fuels provide different quantities of energy and this can be measured experimentally.  |
|  | The quantity of energy released by burning a fuel can be calculated using the formula *Eh = cmΔT.*   |
|  | Specific heat capacity for substances other than water can be determined by rearranging the equation above.  |

**Unit 3: Chemistry in Society**

1. *Metals*

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|  | Metallic bonding is the electrostatic force of attraction between positively charged ions and delocalised electrons.  |
|  | Metal elements (solids, liquids) can conduct electricity due to the free moving electrons.  |
|  | **Reactions of Metals** |
|  | Metals react with oxygen to produce a metal oxide.  |
|  | Metals react with water to produce a metal hydroxide and hydrogen gas. |
|  | Metals react with acid to produce a salt and hydrogen gas. |
|  | Balanced formula and ionic equations can be written to show the reactions above.  |
|  | Differences in the reaction rates give an indication of the reactivity of the metal and allow the construction of the reactivity series of metals.  |
|  | **Electrochemical Cells**  |
|  | Electricity can be produced by connecting different metals together, with an electrolyte, to form a simple cell.  |
|  | The voltage between different pairs of metals varies and this leads to the electrochemical series. The further apart 2 metals in the electrochemical series, the higher the voltage produced.  |
|  | Electricity can also be produced in a cell by connecting two different metals in solutions of their metal ions, and when at least one of the half-cells does not involve metal atoms.  |
|  | Electrons flow through the wires from the species higher in the electrochemical series to the one lower in the electrochemical series.  |
|  | The purpose of the ‘ion bridge’ (salt bridge) is to allow the movement of ions to complete the circuit.  |
|  | **Redox Reactions**  |
|  | Oxidation is a loss of electrons by a reactant in any reaction (e.g. a metal reacting to form a compound).  |
|  | Reduction is a gain of electrons by a reactant in any reaction (e.g. a compound reacting to form a metal).  |
|  | In a redox reaction, reduction and oxidation go on together.  |
|  | Ion-electron equations can be written for oxidation and reduction reactions.  |
|  | Ion-electron equations can be combined to produce redox equations.  |
|  | Electrochemical cells are redox reactions and ion electron and redox equations can be written for these, including those which include non-metals.  |
|  | Fuel cells and rechargeable batteries are two examples of technologies which utilise redox reactions.  |
|  | **Metal Ores**  |
|  | Ores are naturally occurring compounds of metals.  |
|  | The less reactive metals, including gold, silver and copper, are found uncombined in the Earth’s crust and the more reactive metals have to be extracted from their ores.  |
|  | Some metals can be obtained from metal oxides by heat alone; some metal oxides need to be heated carbon; reactive metals must be extracted by electrolysis. The method of extraction is directly related to the reactivity of the metal.  |
|  | From the balanced equations for the extraction of metals the reducing agent can be identified.  |
|  | The percentage of a particular metal in an ore can be calculated.  |

1. *Properties of Plastics*

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|  | Plastics can be made by the processes of addition and condensation polymerisation.  |
|  | Addition polymerisation involves a number of small unsaturated molecules joining together to form a long chain molecule. No other product is formed.  |
|  | Condensation polymerisation involves a number of small molecules reacting together to form a long chain molecule by eliminating a small stable molecule, e.g. water, HCl |
|  | For both types of polymerisation, the structure of a polymer can be drawn from the structure of its monomer(s); and the structure of the monomer(s) can be derived given the structure of the polymer.  |
|  | The type of polymer can be identified from its structure.  |

1. *Fertilisers*

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|  | Plants require three essential elements for growth: Nitrogen, Phosphorus and Potassium.  |
|  | Artificial fertilisers must be soluble, and replace these nutrients in the soil to allow crop production.  |
|  | The Haber Process is one of the most important reactions in fertiliser production as it produces ammonia. |
|  | The Haber process is a reversible reaction. |
|  | Ammonia is a starting material in the production of nitric acid. |
|  | The Ostwald Process uses ammonia to make nitric acid. |
|  | Ammonia and Nitric acid can be reacted together to produce ammonium nitrate which is a good fertiliser.  |

1. *Nuclear Chemistry*

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|  | Radioactive elements can become more stable by giving out alpha, beta or gamma radiation.  |
|  | The three types of radiation have specific properties which can be described including their mass, charge and ability to penetrate different materials.  |
|  | Nuclear equations can be written to describe nuclear reactions.  |
|  | Balanced nuclear equations, involving neutrons, protons, alpha particles and beta particles, can be written. |
|  | The time for half of the nuclei of a particular isotope to decay is fixed and is called the half-life.  |
|  | The quantity of radioisotope, half-life or time elapsed can be calculated given the value of the other two variables. |
|  | Half-life for a particular isotope is a constant so radioactive isotopes can be used to date materials.  |
|  | Radioactive isotopes are used in medicine and industry.  |

1. *Chemical Analysis*

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|  | Chemists play an important role in society by monitoring our environment to ensure that it remains healthy and safe and that pollution is tackled as it arises.  |
|  | A variety of methods exist which enable chemists to monitor the environment. These include:* Acid/base titrations
* Precipitation
* Flame testing
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