National 4 Chemistry Key Areas

**Unit 1 Chemical Changes and Structure**

**1. Rates of reaction**

Reactions monitored and graphs interpreted.A working knowledge of the factors affecting rates of reaction is required for this Course. To compare rates of chemical reactions, changes in mass, volume and other quantities can be measured. Graphs can then be drawn to help this comparison.

**2. Atomic structure and bonding related to properties of material**

A working knowledge of the structure of the periodic table, groups and periods is required for this Course.

All matter is made of atoms. When a substance contains only one kind of atom it is known as an element. Atoms contain protons, neutrons and electrons each with a specific charge, mass and position within the atom. The number of protons defines an element and is known as the atomic number. The mass number of an atom is the number of protons plus neutrons. Atoms do not have an electric charge and are said to be neutral.

Elements are arranged in the periodic table in order of increasing atomic number; elements with similar chemical properties are grouped together. Elements can be categorised as metals and non-metals.

Compounds are substances formed when atoms of two or more elements join together. The name of a compound is derived from the names of the elements from which it is formed with a suffix of -ide, -ite, or -ate. The ratio in which elements combine to form two element compounds can be determined using valency rules. The chemical formula can also be determined from names with prefixes, models or structures.

From the formula of a substance, its formula mass can be calculated using the Relative Formula Mass of the elements.

A chemical reaction which can be described using word equations, can also be described using chemical symbol equations. Use of state symbols in equations.

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To be sure of the bonding present in a substance the properties must be tested.

Covalent compounds, made of molecules, have low melting and boiling points. As a result, they can be found in any state at room temperature. Ionic compounds have high melting and boiling points. As a result, they are found in the solid state at room temperature. Only ionic compounds can conduct electricity, they can only do this when molten or in solution.

**3. Energy changes of chemical reactions**

Reactions can be exothermic or endothermic. This is dependent on the overall energy change taking place.

**4. Acids and bases**

A working knowledge of pH and acids and bases including neutralisation reactions and salt formation is required for this course.

The pH of water can only be affected by the addition of soluble substances. Soluble metal oxides produce alkaline solutions; soluble non-metal oxides produce acidic solutions. Insoluble oxides will not affect the pH of water.

Candidates may have an appreciation that CO2 is a by-product of burning fossil fuels but another large contribution is made by cement manufacturing for use in new buildings. Teachers may wish to use this opportunity to discuss carbon/global footprints Non-metal oxides play a large role in the environment. Carbon dioxide, sulfur dioxide and oxides of nitrogen are produced as a result of our continued use of fossil fuels. Although these oxides are produced in nature the increased production of these oxides is linked to environmental problems including acid rain, global warming and ocean acidification.

Acids play an important role in the food and drink industry. These acids have an impact on human health. A neutralisation reaction is one in which an acid reacts with a base to form water. A salt is also formed in this reaction. Bases are metal oxides, metal carbonates and metal hydroxides. The course of a neutralisation reaction can be followed using a pH indicator; if the base is insoluble an indicator is not required. These reactions can be described through the use of word equations and should include the correct name for the salt.

**Unit 2 Nature’s Chemistry**

**1. Fuels**

A fuel is any compound that has stored energy. Energy is captured in chemical bonds through processes such as photosynthesis and respiration. Energy is released during burning/oxidation. The most common form of oxidation is the direct reaction of a fuel with oxygen through combustion. Ways to reduce carbon dioxide emissions are explored (including methods of carbon capture).Wood, petrol, coal, peat and any number of other fuels have energy-rich chemical bonds created using the energy from the Sun, which is released when the fuel is burned. Chemical fuels or the fossil fuels are useful reserve of fuels and are therefore used extensively to satisfy the demands of an energy-dependent world. Fossil fuels are principally hydrocarbons with minor impurities. They are so named because they originate from the decayed and fossilised remains of plants and animals that lived millions of years ago. They are a finite resource. Crude oil is a mixture of hydrocarbons. Combustion is the reaction of burning a fuel in oxygen. Controlling fires can be explained through the fire triangle. Hydrocarbons burn in a plentiful supply of oxygen to produce carbon dioxide and water. Carbon monoxide, a poisonous gas, and carbon are produced when hydrocarbons burn in a limited supply of oxygen. In engines, catalytic converters can be used to minimise the output of carbon monoxide The concept of conservation of mass will be introduced through equations relating to combustion of hydrocarbons. Combustion of fossil fuels impacts on the environment and contributes to the carbon cycle. Exothermic chemical reactions produce energy and endothermic chemical reactions take in energy. Combustion is an example of an exothermic reaction. Finite energy sources will be investigated in conjunction with the development of biofuels as alternative sources of energy to support society’s energy needs. The benefits and risks of different energy sources and their impact on the carbon cycle can be researched. Biomass, a source of biofuels, is plant-based material which can be burned to release energy. Biomass can also be converted to other usable forms of fuel. These include methane gas or fuels used for transportation such as ethanol and biodiesel.

**2. Hydrocarbons**

Hydrocarbon molecules contain carbon and hydrogen only.

Fractional distillation is the process used for separating crude oil into fractions. The properties and use of the fractions can be compared.

A fraction is a group of hydrocarbons with boiling points within a given range. There are many different hydrocarbon molecules as carbon and hydrogen can form chain molecules of different lengths.

The alkanes are a subset of hydrocarbons and are identified from the ‘-ane’ ending. Straight-chain alkanes can be named and identified from full structural formulae and molecular formulae up to C8.The alkenes are also a subset of hydrocarbons. An alkene can be identified from the carbon-to-carbon double bond and ‘-ene’ ending. Straight-chain alkenes can be named and identified from full structural formulae and molecular formulae up to C8.

**3. Everyday consumer products**

Cracking is a process used to meet the demand for shorter chain alkanes and alkenes.

Plants are a source of carbohydrates and oils which can be used for food or fuel.

Carbohydrates are compounds which contain carbon, hydrogen and oxygen with the hydrogen and oxygen in the ratio of two to one.

Glucose is a simple carbohydrate with the formula C6H12O6.Starch is a complex carbohydrate formed by joining many glucose molecules. Chemical tests can carried out to distinguish between glucose and starch using Benedict’s solution and iodine respectively. Plants convert glucose into starch for storing energy.

Starch is broken down into glucose in the body, during digestion. Glucose, due to its small molecular size, can pass through the gut wall into the bloodstream to be used in cells, throughout the body, during respiration. Enzymes present in yeast can convert glucose into ethanol. This process is called fermentation. Different plants are used to produce different alcoholic beverages. Enzymes operate under optimal conditions, as the fermentation process continues the concentration of ethanol causes the enzyme to stop working. This limits the ethanol concentration achievable by fermentation.

To achieve higher concentrations of ethanol for production of spirits, distillation must be carried out.

The alcohol content of drinks is measured in units.

**4. Plants to products**

Many plants are used by chemists in the design and manufacture of many everyday products such as pharmaceuticals soaps, cosmetics, dyes, medicines, foods or food colourings.

Learners will research and investigate how plants are used to make products. For each plant they should cover: where they are found and grown; the identification of the active ingredient; the role of the chemists in extracting the useful chemicals; the variety of uses and applications of plant-based products and how the plant-based products have enhanced everyday life.

**Unit 3 Chemistry in Society**

**1. Metals and alloys**

Materials are all substances and include metals, ceramics and plastics as well as natural and novel substances. Chemical and physical properties of materials are linked to their uses.

Observation of the reaction of metals with: oxygen, water and dilute acid. Allow for a reactivity series to be deduced.

Methods used to extract metals from their ores are dependent on the position of the metal in the reactivity series. Metals corrode by their reaction with oxygen and water.

Different metals corrode at different rates. The use of certain metals to protect iron from rusting is related to their relative position to iron in the electrochemical series. Ferroxyl indicator can be used to show rusting occurring.

When different metals are connected by an electrolyte, an electric current flows from one metal to the other through connecting wires. By comparing pairs of metals the electrochemical series can be constructed. The electrochemical series is used to predict the size of voltage and direction of current in chemical cells. This forms the basis for batteries.

An alloy is a mixture of two or more elements, at least one of which is a metal. Alloys have different physical properties in comparison to the pure elements.

**2. Materials**

Plastics are a group of important materials. They are long-chain molecules called polymers and can be made by a process called polymerisation. Polymers can be engineered to be used in a variety of environments.

Plastics can be grouped in different ways: thermosoftening and thermosetting plastics.

Thermosoftening plastics or thermoplastics can be reshaped once heated whereas thermosetting polymers cannot. Plastics are made from small units called monomers. The name of the polymer can be deduced from the name of the monomer. Plastics burn to release harmful gases. Plastics have been developed which can biodegrade.

Properties of materials are constantly updated and adapted and new materials developed to meet the demands of society. These tend to have special and unique properties.

The properties of ceramic materials have made them vital components for many modern applications.

**3. Fertilisers**

The chemist has an important role in helping to make sure plants have the correct nutrients to ensure sufficient food production. There are three key elements which provide the nutrients required for plant growth: nitrogen, phosphorus and potassium. The % composition of an element in the fertiliser can be calculated. They are usually shown as percentage amounts on the side of fertiliser packaging.

Fertilisers can be produced naturally or in laboratories by chemists using neutralisation reactions.

The use of fertilisers may have an environmental impact.

**4. Nuclear Chemistry**

Heavier elements are formed from lighter elements in stars. Background radiation is a natural phenomenon and is caused by various factors.

**5. Chemical Analysis**

Chemical analysis permeates all aspects of chemistry. It is important that learners understand the significance of analysis and carry out simple analytical techniques.

Analytical techniques could include:

 chromatography

 flame tests

 pH measurement using indicators / pH meters

 separation techniques