Unit and Year: C1 Air and Water YEAR 9

Purpose of Unit:

1. **How has the earth's atmosphere changed over time, and why?**
2. **Why are there temperatures changes in chemical reactions?**
3. **What is the evidence for climate change, why is it occurring?**
4. **How can scientists help improve the supply of portable water?**

Key Learning/Knowledge:

- To explain the properties of the different states of matter (solid, liquid and gas) in terms of the particle model, including gas pressure.
- To understand the differences between atoms, elements and compounds.
- To be able to correctly use chemical symbols and formulae for elements and compounds.
- To understand conservation of mass, changes of state and chemical reactions.
- To explain changes of state in terms of the particle model.
- To understand that there are energy changes on changes of state (qualitative).
- To describe exothermic and endothermic chemical reactions (qualitative).
- To explain the composition of the Earth's atmosphere today.
- To explore the production of carbon dioxide by human activity and its impact on climate.
- To explain how potable water is produced.

Key Skills:

- Be able to explain the main features of the particle model in terms of changes of state.
- Use data to explain the state of a substance at a given temperature.
- Be able to discuss the causes of air pollution
- Explain methods of reducing emissions
- Be able to write and balance chemical equations.
- Be able to interpret reaction profile plots.
- Know that the unit of Enthalpy is kJ/mol
- Be able to describe an experiment to determine if a reaction is endothermic or exothermic.
- Perform tests to identify oxygen, hydrogen and carbon dioxide and chlorine (PAG 2).
- Analyse data on global warming.
- Explain processing of wastewater to produce potable water.

Key Vocabulary and meanings:

Combustion – burning of fuel to produce water and carbon dioxide.
Incomplete combustion - burning of fuel in low amounts of oxygen.
Atmosphere – the mixture of gases that surround a planet.
Global Warming – increase in temperature of planet caused by pollution.
Climate Change – changes to the climate caused by global warming.
Greenhouse Effect – insulating effect that gases in the atmosphere provide.
Acid Rain – acid produced by pollution that falls as rain.
Exothermic – transfer of heat energy to surroundings.
Endothermic – transfer of heat energy from the surroundings.
Activation Energy – energy required to allow a chemical reaction to occur.
Enthalpy – overall change in energy.
Oxidation – gain of oxygen.
Reduction – loss of oxygen.
Fuel Cell – used to convert chemical energy to electrical energy.
Potable water – water that is safe to drink.

Links to prior knowledge/learning:

- Builds on "Elements and Compounds" unit from Year 7
- Develops Maths skills using calculations to determine overall energy changes.
- Develops Maths skills using ratios to balance chemical equations.
- Develops Maths skills to calculate mean, median and range of data.

Unit and Year: C2 – Chemical Patterns YEAR 9

Purpose of Unit:

1. How have our ideas about atoms developed over time?
2. What does the Periodic Table tell us about the elements?
3. How do metals and non-metals combine to form compounds?
4. How are equations used to represent chemical reactions?
5. What are the properties of the transition metals?

Key Learning/Knowledge:

- To understand Bohr's model of the atom, the charges and structure and the relative sizes and masses.
- To draw the electronic structure of different atoms.
- To understand and explain the physical and chemical properties of group 1 elements.
- To understand and explain the physical and chemical properties of group 7 elements.
- To understand and explain the physical and chemical properties of group 0 elements.
- To describe the properties of transition metals.
- To describe and explain the properties of ionic compounds.
- To draw the electronic structure of ions in ionic bonding.

Key Skills:

- To understand how scientific explanations and models develop in context of changing ideas about the atomic model and periodic table.
- To make predictions about trends and patterns in the Periodic Table.
- To test the properties of ionic compounds.
- PAG 1 - To describe experiments to identify the reactivity pattern of Group 7 elements including displacement reactions.
- To calculate the numbers of protons, neutrons and electrons of an atom/ion as well as the mass of isotopes.
- To evaluate the representations of models of ionic bonding (Dot-and-cross, 2D and 3D.
- To investigate colours of transition metal compounds, and their effectiveness as catalysts.

Key Vocabulary and meanings:

Atom – The smallest particle of a chemical element that can exist.
Subatomic particle – The smaller parts that make up an atom.
Element – A substance made from one type of atom.
Atomic number – The number of protons in an atom.
Mass number – The total average number of protons and neutrons in the nucleus of an atom.
Proton – A subatomic particle, with a positive charge, found in the nucleus of an atom.
Neutron – A subatomic particle, with no charge, found in the nucleus of an atom.
Electron – A tiny, negatively charged subatomic particle that is found in the shells.
Nucleus – The tiny centre of an atom containing the protons and neutrons.
Electron shells – The energy levels outside the nucleus of an atom where electrons are found.
Isotope – Two or more forms of the same element with different numbers of neutrons.
Periodic Table – A table of all of the known elements in order of increasing atomic number.
Period – A horizontal row across the Periodic Table.
Group – A vertical column of the periodic table.
Displacement Reaction – A more reactive element takes the place of a less reactive element in a compound.
Catalyst – A substance that increases the rate of reaction but is left unchanged.
Inert – Does not readily react.
Ion – A charged atom or group of atoms.
Ionic bonding – The strong attraction between a positively charged metal ion and a negatively charged non-metal ion.
Electrostatic force – The attraction between objects with opposite charges.
Lattice - A regular repeated three-dimensional structure.

Links to prior knowledge/learning:

- Builds on 'Periodic Table' unit from Year 7.
- Develops Maths skills, calculating numbers of protons, neutrons and electrons as well as isotope masses.

Unit and Year: C3 Combined. Chemicals of the natural environment (Higher in bold)

Purpose of Unit:

1. How are atoms held together in a metal?
2. How are metals with different reactivities extracted?
3. What are electrolytes and what happens during electrolysis?
4. Why is crude oil important as a source of new materials?

Key Learning/Knowledge:

- Describe nature and arrangement of chemical bonds in metals.
- Explain and relate bulk properties of metals to metallic bonding.
- Deduce order of metal reactivity series experimentally and link increased reactivity to tendency of metal to form positive metal ions.
- Describe carbon reduction and electrolysis as methods of metal extraction. Know when each method is applicable.
- **Evaluate alternative biological methods of extraction.**
- Describe the use of electrolysis more widely and identify species that are oxidised or reduced.
- Write formulae and balanced chemical equations and **ionic equations.**
- Recognise importance of crude oil and describe its extraction by fractional distillation. Relate boiling point to inter molecular forces.
- Assess different methods of representing substances.

Key Skills:

- Use reactivity series to determine methods of extraction and products of displacement reactions.
- Balance chemical equations.
- Deduce empirical formulae.
- Explain relationship between b.p and inter molecular forces.

Key Vocabulary and meanings:

Redox – short for reduction and oxidation.
Reduction – loss of oxygen or **gain of electrons**.
Oxidation – gain of oxygen or **loss of electrons**.
Ions – charged particles.
Electrolysis – splitting of compounds using electricity.
PANIC – positive anode negative is cathode.
OILRIG – oxidation is loss of electrons reduction is gain.
Inter molecular forces – forces of attraction between separate molecules.
Empirical formula – lowest whole number ratio of atoms in a molecule.
Molecular formula – gives the number of each element present in a molecule.
Structural formula – graphic representation of how the atoms are arranged in a molecule.
Fractional distillation – Process by which different sized molecules in crude oil are separated.

Links to prior knowledge / learning:

Builds on KS3 work on metals and chemical equations

Unit and Year: C3 Triple Chemicals of the natural environment (Higher in bold)

Purpose of Unit:

1. How are atoms held together in a metal?
2. How are metals with different reactivities extracted?
3. What are electrolytes and what happens during electrolysis?
4. Why is crude oil important as a source of new materials?

Key Learning/Knowledge:

- Describe nature and arrangement of chemical bonds in metals.
- Explain and relate bulk properties of metals to metallic bonding.
- Deduce order of metal reactivity series experimentally and link increased reactivity to tendency of metal to form positive metal ions.
- Describe carbon reduction and electrolysis as methods of metal extraction. Know when each method is applicable.
- **Evaluate alternative biological methods of extraction.**
- Describe the use of electrolysis more widely and identify species that are oxidised or reduced in molten and aqueous solutions.
- Describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present.
- Write formulae and balanced chemical equations, **ionic equations and half equations.**
- Recognise importance of crude oil and describe its extraction by fractional distillation. Relate boiling point to inter molecular forces.
- Assess different methods of representing substances.
- Represent different functional groups up to first four members of homologous series.
- Describe simple reactions of functional groups.

Key Skills:

- Use reactivity series to determine methods of extraction and products of displacement reactions.
- Balance chemical equations.
- Deduce empirical formulae.
- Explain relationship between b.p and inter molecular forces.

Key Vocabulary and meanings:

Redox – short for reduction and oxidation.
Reduction – loss of oxygen or gain of electrons.
Oxidation – gain of oxygen or loss of electrons.
Ions – charged particles.
Electrolysis – splitting of compounds using electricity.
PANIC – positive anode negative is cathode.
OILRIG – oxidation is loss of electrons reduction is gain.
Inter molecular forces – forces of attraction between separate molecules.
Empirical formula – lowest whole number ratio of atoms in a molecule.
Molecular formula – gives the number of each element present in a molecule.
Structural formula – graphic representation of how the atoms are arranged in a molecule.
Homologous series – series of compounds with the same functional group differing by an increment of CH_2 each time.
Functional group – a group of atoms within a molecule with distinctive chemical properties.

Links to prior knowledge / learning:

Builds on KS3 work on metals and chemical equations

Unit and Year: Yr 10 C4 Combined Material choices. (Higher in bold)

Purpose of Unit:

1. How is data used to choose materials for particular uses?
2. How do bonding and structure affect properties of materials?
3. Why are nanoparticles useful?
4. What happens to products at the end of their useful life?

Key Learning/Knowledge:

- Quantitative comparison of physical properties of a variety of materials.
- Explanation of relationship between material properties and use.
- Recall addition polymerisation in terms of monomer functional group and polymer repeat unit.
- Explain material properties by relating type of bonding to structure to properties.
- Recall carbons ability to form 4 bonds and to bond to itself.
- Describe how to alter polymer properties.
- Compare and contrast the giant covalent structures of diamond and graphite.
- Use and comparison of different representations of structure.
- Nanoparticles- recall relative dimensions, describe special properties in relation to surface area to volume ratio. Give examples of nano technology and weigh up risks and benefits.
- Describe corrosion and its mitigation.
- REDOX in terms of gain and loss of oxygen and **in terms of OILRIG.**
- Describe basic principles of product life cycle assessment (with reference to PET bottles).
- Evaluate comparative environmental impact.

Key Skills:

- Compare sets of data for real difference.
- Represent polymer reactions.
- Link properties to type of bonding.
- Identify chemical species in REDOX
- Calculations of volumes, surface areas and scale using standard form and ratios.

Key vocabulary and meanings:

Range-Measure of variability, given as the difference between the largest and smallest results.
Mean-Sum of a group of measurements divided by the number of measurements.
Real difference- Deduced by comparing the ranges and means of sets of data in an experiment.
Monomer- Atoms or small molecules that combine to form polymers.
Polymer – Very large molecules made up of repeating sub-units called monomers.
Nanometre –(nm) 10^{-9}m
Nanotechnology –Use and control of very small molecules between 1 and 100nm.
Corrosion –Reaction of metal surface with oxygen and water that weakens the metal.
OILRIG – Oxidation is loss of electrons reduction is gain.
Redox – Short for reduction and oxidation.
Reduction – Loss of oxygen or gain of electrons.
Oxidation – Gain of oxygen or loss of electrons.
LCA- Life Cycle Assessment. Measurement of the environmental impact of a product throughout life cycle.

Links to prior knowledge/learning:

- REDOX reactions from C3

Unit and Year: Yr 10 C4 Triple Material choices. (Higher in bold)

Purpose of Unit:

1. How is data used to choose materials for particular uses?
2. What are the different types of polymers?
3. How do bonding and structure affect properties of materials?
4. Why are nanoparticles useful?
5. What happens to products at the end of their useful life?

Key Learning/Knowledge:

- Quantitative comparison of physical properties of a variety of materials.
- Explanation of relationship between material properties and use.
- Compositional description of important alloys.
- Recall addition polymerisation in terms of monomer functional group and polymer repeat unit.
- **Explain basic condensation polymerisation in terms of monomer functional groups and products of polymerisation. Also environmental implications of reversibility of condensation reactions.**
- Recall of structure of DNA.
- Explain material properties by relating type of bonding to structure to properties.
- Recall carbons ability to form 4 bonds and to bond to itself.
- Describe how to alter polymer properties.
- Compare and contrast the giant covalent structures of diamond and graphite.
- Use and comparison of different representations of structure.
- Nanoparticles- recall relative dimensions, describe special properties in relation to surface area to volume ratio. Give examples of nanotechnology and weigh up risks and benefits.
- Describe corrosion and its mitigation.
- REDOX in terms of gain and loss of oxygen and **in terms of OILRIG.**
- Describe basic principles of product life cycle assessment (with reference to PET bottles).
- Evaluate comparative environmental impact.

Key Skills:

- Compare sets of data for real difference.
- Represent polymer reactions.
- Link properties to type of bonding.
- Identify chemical species in REDOX
- Calculations of volumes, surface areas and scale using standard form and ratios.

Key vocabulary and meanings:

Range-Measure of variability, given as the difference between the largest and smallest results.

Mean-Sum of a group of measurements divided by the number of measurements.

Real difference-deduced by comparing the ranges and means of sets of data in an experiment.

Monomer- atoms or small molecules that combine to form polymers.

Polymer – Very large molecules made up of repeating sub-units called monomers.

Nanometre –(nm) 10^{-9}m.

Nanotechnology –use and control of very small molecules between 1 and 100nm.

Corrosion –reaction of metal surface with oxygen and water that weakens the metal.

OILRIG – oxidation is loss of electrons reduction is gain.

Redox – short for reduction and oxidation.

Reduction – loss of oxygen or gain of electrons.

Oxidation – gain of oxygen or loss of electrons.

LCA-Life cycle assessment. Measurement of the environmental impact of a product throughout life cycle.

Links to prior knowledge/learning:

- REDOX from C3

Unit and Year: C5 – Chemical Analysis Combined Science

Purpose of Unit:

1. **Pure substances, mixtures and formulations**
2. **How are chemicals separated and tested for purity?**
3. **How are the amounts of substances in reactions calculated?**
4. **How are the amounts of chemicals in solutions measured?**

Key Learning/Knowledge:

- Identify substances as pure, mixtures or formulations
- Describe how reference samples and R_f values are used in chromatography to identify unknown samples
- Describe and explain the processes of filtration, crystallisation, distillation and fractional distillation
- Suggest suitable separation techniques for different types of mixtures
- Recall and use the law of conservation of mass
- Explain observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model
- Calculate the relative formula mass of species separately and in a balanced chemical equation
- **Calculate amounts of substance in moles**
- **Use of the Avagadro constant**
- **Deduce the stoichiometry of an equation from reacting masses**
- **Explain the effect of a limiting quantity of a reactant**
- **Calculate concentrations both in g/dm^3 and mol/dm^3**
- Use ratios, percentages and multistep calculations throughout quantitative chemistry
- Describe neutralisation reactions in terms of hydrogen ions and hydroxide ions
- Describe and explain the procedure for a titration to give results which are precise, accurate, valid and repeatable

Key Skills:

- To carry out common separation techniques
- To carry out titrations
- **Calculate the amount, in moles, of solid samples**
- **Calculate the amount, in moles, of samples in solution**

Formulation mixtures that are prepared to a specific formula

Concentration the amount (in grams or moles) of solid dissolved in 1 dm^3 of water

Quantitative Analysis any method used to identify **how much** of a chemical is present in a sample

Qualitative Analysis any method used to identify **which** chemicals are present in a sample

Avagadro Constant the number of particles in a mole of any substance (6.0×10^{23})

Molar Mass the mass of one mole of a substance

Neutralisation a reaction in which an acid reacts with an alkali to form a salt

Links to prior knowledge/learning:

- Builds on prior knowledge of solids, liquids and gases to decide how mixtures might be separated
- Prior knowledge of the pH scale for measuring acidity and alkalinity

Unit and Year: C5 – Chemical Analysis

Purpose of Unit:

1. **How are chemicals separated and tested for purity?**
2. **How do chemists find the composition of unknown samples?**
3. **How are the amounts of substances in reactions calculated?**
4. **How are the amounts of chemicals in solutions measured?**

Key Learning/Knowledge:

- Identify substances as pure, mixtures or formulations
- Describe how reference samples and R_f values are used in chromatography to identify unknown samples
- Describe and explain the processes of filtration, crystallisation, distillation and fractional distillation
- Suggest suitable separation techniques for different types of mixtures
- Interpret flame tests and emission spectra
- Describe test tube tests used to identify aqueous cations and anions
- Recall and use the law of conservation of mass
- **Calculate amounts of substance in moles**
- **Use of the Avagadro constant**
- **Deduce the stoichiometry of an equation from reacting masses**
- **Explain the effect of a limiting quantity of a reactant**
- Calculate percentage yield for given reactions
- **Calculations involving the molar gas volume**
- **Calculate concentrations both in g/dm^3 and mol/dm^3**
- Describe neutralisation reactions in terms of hydrogen ions and hydroxide ions
- Describe and explain the procedure for a titration to give results which are precise, accurate, valid and repeatable

Key Skills:

- To carry out common separation techniques
- To carry out titrations
- Calculate the amount, in moles, of solid samples
- Calculate the amount, in moles, of samples in solution

Formulation mixtures that are prepared to a specific formula

Concentration the amount (in grams or moles) of solid dissolved in 1 dm^3 of water

Quantitative Analysis any method used to identify **how much** of a chemical is present in a sample

Qualitative Analysis any method used to identify **which** chemicals are present in a sample

Avagadro Constant the number of particles in a mole of any substance (6.0 x 10^{23})

Molar Mass the mass of one mole of a substance

Neutralisation a reaction in which an acid reacts with an alkali to form a salt

Links to prior knowledge/learning:

- Builds on prior knowledge of solids, liquids and gases to decide how mixtures might be separated
- Prior knowledge of the pH scale for measuring acidity and alkalinity

Unit and Year: C6 – Making Useful Chemicals Triple Science

Purpose of Unit:

1. **What useful products can be made from acids?**
2. **How do chemists control the rate of reactions?**
3. **What factors affect the yield of a reaction?**
4. **Why the Haber Process employs the conditions that it does**

Key Learning/Knowledge:

- Characteristic reactions of acids with metals, metal oxides, metal hydroxides and metal carbonates to produce salts
- Practical procedures for making salts
- How to measure pH using indicators and pH meters
- **Correctly use the terms weak, strong, dilute and concentrated when describing acids**
- **Describe the relationship between hydrogen ion concentration and pH**
- How to measure the rate of change with respect to the disappearance of a reactant or the formation of a product
- Recall the way in which concentration, temperature, pressure, particle size and catalysts affect the rate of chemical change
- Use collision theory to explain these changes
- Explain the effect of catalysts with reference to activation energy
- The use of enzymes as biological catalysts
- How to process graphs and numerical data for reaction rates
- Define the terms dynamic equilibrium and reversible reaction
- **Predict the effects of given changes to reaction conditions on the position of equilibrium**
- **Recognise the importance of nitrogen fixing**
- **Recall the main stages in the industrial manufacture of fertilisers and compare them with laboratory processes**

Key Skills:

- Practical procedures for measuring rates of chemical reactions
- Practical procedures for producing salts
- Interpreting reaction rate graphs
- Calculate percentage yield for given reactions
- Interpreting graphs of percentage yield versus pressure at different temperatures

Acid A substance which produces hydrogen ions when it dissolves in water
Alkali A substance which dissolves in water to produce hydroxide ions
Catalyst A substance which increases the rate of a reaction without itself being used up
Salt An ionic compound formed when a an acid reacts with a metal or metal compound
Activation Energy The minimum energy required for to colliding particles to react
Concentration The amount of a solid dissolved in a litre of water
Dynamic Equilibrium When the rate of the forward reaction is equal to the rate of the backward reaction
Reaction Rate The rate at which a reactant is used up or a product is formed
Tangent A straight line touching a curve which has the same gradient as the curve at that point
Nitrogen Fixation The conversion of nitrogen into compounds accessible by plants

Links to prior knowledge/learning:

- Prior knowledge of the pH scale for measuring acidity and alkalinity
- Use of formulae and equations to represent chemical reactions
- Knowledge of exothermic and endothermic reactions

Unit and Year: C6 – Making Useful Chemicals Combined Science

Purpose of Unit:

1. **What useful products can be made from acids?**
2. **How do chemists control the rate of reactions?**
3. **What factors affect the yield of a reaction?**

Key Learning/Knowledge:

- Characteristic reactions of acids with metals, metal oxides, metal hydroxides and metal carbonates to produce salts
- Practical procedures for making salts
- How to measure pH using indicators and pH meters
- How to measure the rate of change with respect to the disappearance of a reactant or the formation of a product
- Recall the way in which concentration, temperature, pressure, particle size and catalysts affect the rate of chemical change
- Use collision theory to explain these changes
- Explain the effect of catalysts with reference to activation energy
- The use of enzymes as biological catalysts
- How to process graphs and numerical data for reaction rates
- Define the terms dynamic equilibrium and reversible reaction
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Key Skills:

- Practical procedures for measuring rates of chemical reactions
- Practical procedures for producing salts
- Interpreting reaction rate graphs

Acid A substance which produces hydrogen ions when it dissolves in water
Alkali A substance which dissolves in water to produce hydroxide ions
Catalyst A substance which increases the rate of a reaction without itself being used up
Salt An ionic compound formed when a an acid reacts with a metal or metal compound
Activation Energy The minimum energy required for to colliding particles to react
Concentration The amount of a solid dissolved in a litre of water
Dynamic Equilibrium When the rate of the forward reaction is equal to the rate of the backward reaction
Reaction Rate The rate at which a reactant is used up or a product is formed
Tangent A straight line touching a curve which has the same gradient as the curve at that point

Links to prior knowledge/learning:

- Prior knowledge of the pH scale for measuring acidity and alkalinity
- Use of formulae and equations to represent chemical reactions
- Knowledge of exothermic and endothermic reactions