

BTEC Level 3 Nationals in Applied Science – Chemistry Personal Learning Checklist

A1 Structure and Bonding in Applications of Science				
Electronic Structure	Know that atoms have electron shells / energy levels which consist of subshells (s, p and d).			
	Know the number and type of subshells in the first four energy levels.			
	Know how to place these subshells in order of increasing energy.			
	Be able to write the electronic structure (configuration) of the first 36 elements of the periodic table using s, p and d subshell notation.			
Electronic Orbitals	Know that subshells contain electronic (atomic) orbitals.			
	Know that an orbital is a region of space where an electron is likely to be found.			
	Know that an orbital can hold up to 2 electrons.			
	Know the shapes and orientation of s and p orbitals.			
	Be able to interpret electron density plots for s and p orbitals.			
	Know the number and type of orbitals in each subshell for the first 36 elements.			
Aufbau principle	Understand that to predict the electronic configuration of an atom, electrons fill the shells, subshells and orbitals of lowest energy first.			
	Understand that orbitals with the same energy must be filled singly before electrons are paired.			
	Understand that when electrons are paired, the spins of the two electrons are opposite to each other, in order to reduce repulsion.			
	Be able to use the electron-in-box model to show how electrons fill the orbitals in atoms of the first 36 elements.			
Bohr theory	Understand that electrons occupy shells or energy levels, orbiting the nucleus of the atom.			
	Understand that an electron can move from its ground state energy level to a higher energy level by absorption of a quantum of radiation.			
	Understand that an electron can move from an excited state energy level to a lower energy level by emitting a quantum of radiation.			
Ionic Bonding	Be able to predict whether a compound has ionic bonding from its name or formula.			
	Be able to predict the formula of an ionic compound from its elements (for groups 1, 2, 3, 6 and 7).			
	Understand how the physical properties of ionic substances, such as melting and boiling point, solubility and electrical conductivity, are affected by their bonding and structure.			

Ionic Bonding	Understand that ionic bonding is a result of strong electrostatic attraction between positive and negative ions.			
	Understand that electrostatic attraction between ions can occur in any direction.			
	Understand that a giant ionic structure is a lattice of many ions held together by electrostatic attraction.			
Effect of Ionic Radius and Charge	Understand that the strength of electrostatic attraction increases with increasing ionic charge.			
	Understand that the strength of electrostatic attraction decreases with increasing size of ionic radius.			
	Understand why ionic radius increases down a group.			
	Understand how ionic radius changes across a period (for groups 1, 2, 3, 5, 6 and 7).			
	Be able to predict differences in the strength of ionic bonding for different ionic compounds.			
Formation of Ions	Be able to describe the formation of positive ions (cations) by the loss of electron(s) from metal atoms.			
	Be able to describe the formation of negative ions (anions) by the gain of electron(s) by non-metal atoms.			
	Be able to draw dot-and-cross diagrams for ionic compounds of groups 1, 2, 3, 6 and 7 elements, showing outer electrons and correct charges.			
	Be able to write the electronic structure (configuration) of cations and anions, using s, p and d subshell notation for the first 35 elements.			
Covalent Bonding	Be able to predict if a compound has covalent bonding from its name or formula.			
	Understand how the physical properties of covalent substances, such as melting and boiling point, solubility and electrical conductivity, are affected by their bonding and structure (to include simple molecular and giant covalent structures).			
	Understand that covalent bonding involves the sharing of a pair of electrons between two atoms and that there is strong electrostatic attraction between the nuclei and the electrons being shared.			
	Understand that electrostatic attraction between nuclei and the shared electrons is localised and in a specific direction.			
	Understand that a giant covalent structure is a lattice of many atoms bonded covalently.			

Covalent Bonding	Be able to draw dot-and-cross diagrams for simple covalent molecules, showing outer electrons.			
	Know that multiple bonds involve two or more pairs of electrons being shared.			
	Know that a dative covalent (coordinate) bond is a covalent bond in which the pair of electrons being shared is donated by one atom.			
	Understand that as the number of shared pairs of electrons between two atoms increases, the bond length decreases.			
	Understand that as the number of shared pairs of electrons between two atoms increases, the bond strength increases.			
	Be able to represent covalent bonds in substances as 2D line diagrams.			
	Understand that electron pairs in bonds repel each other in order to be as far apart as possible around a central atom.			
	Know the bond angle associated with 4 bonding electron pairs around a central carbon atom is 109.5° .			
	Be able to represent covalent bonds in simple organic molecules as 3d line diagrams.			
Metallic Bonding	Be able to predict if a substance has metallic bonding from its name or symbol.			
	Know that the structure of a metal is a lattice of positive metal ions surrounded by delocalised electrons.			
	Know that metallic bonding is the electrostatic attraction between the nuclei of the positive metal ions and the delocalised electrons.			
	Understand that delocalised electrons are formed by the loss and free movement of the outer shell electrons from the metal atoms.			
	Understand that electrostatic attraction between positive ions and delocalised electrons can occur in any direction.			
	Understand that a giant metallic structure is a lattice of many atoms held together in regular layers by metallic bonding.			
	Be able to describe or draw diagrams to show the structure of a metal and metallic bonding.			
	Understand how the chemical and physical properties of metals, such as melting and boiling point, malleability, ductility and electrical conductivity, are affected by their bonding and structure.			

Intermolecular Forces	Know that simple covalent molecules are held together by relatively weak intermolecular forces.			
	Know the three main types of intermolecular forces and their relative strengths.			
	Be able to predict the intermolecular forces present in given molecules or monatomic substances to include hydrogen and elements of group 5, 6, 7 and 0 and the hydrides of group 4, 5, 6 and 7 elements and explain how they arise.			
	Be able to explain differences in physical properties (such as melting point, boiling point and density) for different molecules or monatomic substances, in terms of the intermolecular forces present.			
	Understand that van der Waals forces is the term used for intermolecular forces that involve dipole attraction between molecules.			
	Understand that temporary dipoles in molecules can form due to the uneven distribution of electrons.			
	Understand that an induced dipole can be created in a neighbouring molecule and a weak attraction between the molecules can occur.			
	Understand that the size and strength of the temporary dipole - induced dipole attraction depends upon the number of electrons.			
	Understand how molecular size and shape also affects the strength of the temporary dipole – induced dipole.			
	Know that permanent dipole – permanent dipole attraction can occur in polar molecules and is stronger than temporary dipole – induced dipole attraction in the same molecule.			
	Understand that permanent dipoles arise from a difference in electronegativity between the two atoms bonded.			
	Understand that the greater the difference in electronegativity between the two atoms, the greater the strength of the permanent dipole.			
	Know that hydrogen bonding is a relatively strong intermolecular force compared to dipole-dipole attraction, but much weaker than covalent bonding.			
	Understand that hydrogen bonding occurs in polar molecules which have N-H, O-H or H-F bonds.			
	Be able to explain how hydrogen bonding occurs.			
	Be able to draw examples of molecules with hydrogen bonding, such as H ₂ O, NH ₃ , HF, and organic molecules with an O-H group.			

Balanced Equations	Know the formula of common substances such as water, carbon dioxide, oxygen, hydrogen, nitrogen and the halogens			
	Be able to work out the formulae of common ions of elements from their position in the periodic table.			
	Know the formulae of ions containing more than one element, such as hydroxide (OH^-), carbonate (CO_3^{2-}), sulfate (SO_4^{2-}), nitrate (NO_3^-), ammonium (NH_4^+).			
	Be able to work out the formulae for ionic compounds from the charges on their ions.			
	Be able to write balanced chemical and ionic equations for reactions in this learning aim.			
	Know the state symbols (s), (l), (g) and (aq), and use them in balanced equations.			
Relative Molecular Mass	Be able to use the periodic table to find the atomic number or relative atomic mass for an element.			
	Be able to determine the number of protons or electrons in an atom or ion from the atomic number.			
	Be able to calculate relative molecular mass (or relative formula mass) of a compound from the sum of the relative atomic masses of all the atoms present.			
Atomic number	Be able to use the periodic table to find the atomic number or relative atomic mass for an element			
	Be able to determine the number of protons or electrons in an atom or ion from the atomic number			
	Be able to calculate relative molecular mass (or relative formula mass) of a compound from the sum of the relative atomic masses of all the atoms present			
Moles & Molar masses	Define 1 mole of any substance as a substance that contains the same number of particles as there are atoms in 12.00g of carbon-12			
	That the number of particles in 1 mole is 6.02×10^{23} (known as the Avogadro constant)			
	Convert moles into number of particles using the Avogadro constant (and the reverse)			

Molarity	Recall that the molar mass of a substance is the mass in grams of 1 mole of the substance (and is the same as the relative atomic mass or relative formula mass expressed in g mol^{-1})			
	Understand that the molarity is the number of moles of a substance dissolved in water to produce a volume of 1 dm^3 of a solution and has units of mol dm^{-3}			
Mass, volume of solution	Be able to perform calculations involving the mass of a substance, the number of moles and the molar mass			
	Be able to perform calculations involving the concentration (molarity) of a solution, the number of moles and volume of the solution			
	Be able to perform calculations involving the concentration of a solution in g dm^{-3} , the mass of the substance dissolved and volume of solution			
	Be able to determine whether a reactant is a limiting reagent or in excess			
Reacting quantities	Be able to calculate quantities of masses for substances reacting or produced, using balanced chemical equations, moles and molar mass.			
	Be able to calculate quantities of concentration for reacting substances, using balanced chemical equations, moles and volume			
Percentage yields	Be able to calculate percentage yield of a product from the actual yield (experimental mass) and the theoretical yield (predicted mass)			

A2 Production and uses of substances in relation to properties				
Periodic table	Understand that elements are arranged in order of increasing atomic number.			
	Understand that elements are also arranged in columns called groups and rows called periods.			
	Know where metals and non-metals are located in the periodic table.			
Periods 1, 2, 3 & 4	Understand that all elements in the same period have the same number of occupied shells in their atoms.			
	Be able to determine the period that an element belongs to from its electronic configuration or atomic number.			
	Understand periodic trends across the first four periods in terms of electronic configuration.			
Groups – s block, p block, d block	Understand that all elements in a group have the same number of electrons in the outermost shell of their atoms.			
	Be able to determine the group of an element by using its electronic configuration or atomic number.			
	Understand that elements in the same group have similar chemical behaviour.			
	Be able to explain the change in chemical reactivity of elements in a group using electronic configuration.			
	Know that the s block consists of group 1 and 2 elements, the p block consists group 3 – 8 elements, and that d block elements are located between the s and p blocks.			
	Understand that the order of s, p and d blocks in the periodic table relates to the order in which s, p and d subshells are filled with electrons.			
	Know that the highest subshell occupied by electrons will determine which block of the periodic table an element is found in.			
Electrons	Be able to represent the electronic arrangement of all elements in the first four periods using s, p and d subshell notation.			
	Understand that the electronic arrangement determines the chemical properties of an element.			
1st Ionisation	Know that the first ionisation energy is the energy required to remove one mole of electrons from one mole of atoms in their gaseous state.			
	Understand why first ionisation is always an endothermic process.			
	Be able to write an equation to show first ionisation energy for an element using the general equation, $X(g) \rightarrow X^+(g) + e^-$			

Reasons for trends	Know that the trend in ionisation energy decreases down a group.			
	Know that the general trend in ionisation energy increases across a period but that there are anomalies at group 3 and group 6.			
	Be able to explain trends in ionisation energy in terms of nuclear attraction, nuclear charge, shells, shielding and atomic radius			
	Be able to explain anomalies in ionisation energy trends in terms of changes in energy level, subshell or electron pairing.			
	Understand that successive ionisation energies provide evidence of quantum shells and the group to which the element belongs .			
	Understand that the first ionisation energies of successive elements provide evidence for the existence of electron subshells			
Electron affinity	Know that the first electron affinity is the energy released when 1 mole of gaseous atoms gain one mole of electrons.			
	Understand why first electron affinity is an exothermic process, but successive electron affinities are endothermic.			
	Be able to write an equation to show first electron affinity for an element using the general equation, $X(g) + e^- \rightarrow X^-(g)$			
Radius	Know how atomic radius changes across a period and down a group.			
	Be able to explain trends in atomic radius changes in terms of electron shells, nuclear attraction, nuclear charge and shielding			
Ionic Radius	Know how ionic radius changes across a period and down a group, for both positive and negative ions.			
	Be able to explain differences in size between atomic radii, ionic radii of positive ions and ionic radii of negative ions			
Electronegativity	Know that electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons in a covalent bond.			
	Be able to explain trends in electronegativity across a period and down a group			

Type of bonding	Know that the type of bonding changes from metallic to covalent across a period.			
	Know that the type of structure changes from giant structures to simple molecular structures across a period.			
	Be able to explain the change in bonding and structure across a period.			
	Know that bonding in elements becomes more metallic in character down a group.			
	Be able to explain why the bonding in elements becomes more metallic down a group.			
Trends	Be able to explain changes of state (at melting and boiling point) in terms of particle movement and energy.			
	Know the trends in melting and boiling point across a period and down a group.			
	Be able to explain trends in melting point and boiling point in terms of bonding and structure of elements.			
Physical properties of metals	Know the physical properties of metals (electrical conductivity, thermal conductivity, malleability and ductility).			
	Be able to explain the physical properties of metals in terms of bonding and structure.			
	Be able to compare the physical properties of metals with those of non-metals.			
Products and Reactivity	Know how all period 2 and period 3 elements react with oxygen.			
	Be able to predict the formulae of simple oxides of period 2 and 3 elements.			
	Be able to write balanced equations for the reactions of these elements with oxygen.			
	Understand why incomplete combustion might take place and predict the products.			
	Know the bonding and structure of simple oxides of period 2 and 3 elements.			
	Know how the bonding of simple oxides changes across periods 2 and 3, from ionic to covalent.			
	Know how the structure of simple oxides changes across periods 2 and 3, from giant structures to simple molecular structures.			
	Know and be able to explain the properties of simple oxides of period 2 and 3 elements (melting and boiling points, solubility in water and acid-base nature)			

	Be able to predict the reactions of metals (groups 1 and 2, and period 4 transition metals) with: <ul style="list-style-type: none"> o oxygen to give oxides o water (cold, hot and steam) to give hydroxides or oxides, and hydrogen o dilute acids (HCl or H₂SO₄) to give chlorides or sulfates, and hydrogen 			
	Be able to provide expected observations, such as fizzing and flame colour, where a reaction takes place.			
	Be able to predict the formulae of the products from these reactions: <ul style="list-style-type: none"> • be able to write balanced chemical and ionic equations for these reactions • know the bonding and structure of products from these reactions • know and be able to explain the properties of these products (melting and boiling points, solubility in water and acid-base nature) 			
Reactivity Series	Know that the trend in reactivity of metals increases down groups 1 and 2 and decreases across periods 2 and 3.			
	Be able to explain the trend in reactivity of metals down groups and across periods in terms of nuclear attraction for outer shell electrons, nuclear charge, shielding and atomic radius.			
	Be able to predict the position of a metal in the reactivity series from its position in the periodic table.			
Oxidation	Understand that oxidation is the loss of electrons or the gain of oxygen.			
	Be able to determine the oxidation number (oxidation state) of an element on its own, in a compound or in an ion.			
	Be able to identify an element that is oxidised in an equation			
	Be able to show how an element is oxidised, in terms of an increase in oxidation number (oxidation state).			
	Be able to write chemical equations and half equations showing oxidation.			
Reduction	Understand that reduction is the gain of electrons or the loss of oxygen .			
	Be able to identify an element that is reduced in an equation.			
	Be able to show how an element is reduced, in terms of a decrease in oxidation number (oxidation state).			
	Be able to write chemical equations and half equations showing reduction.			
Ox states	Understand that transition metals can have ions with different oxidation numbers (oxidation states).			
	Be able to determine the oxidation number (oxidation state) of a transition metal in an ion or ionic compound.			

Displacement reactions	Understand that displacement reactions are redox reactions (simultaneous reduction and oxidation).			
	Be able to predict the outcome of displacement reactions between a metal and a compound of a different metal, based upon the relative reactivity of the metals for group 2 and 3 metals and period 4 transition metals.			
	Be able to predict the outcome of displacement reactions between a halogen and a halide, based upon the relative reactivity of group 7 elements.			
	Be able to provide expected observations, such as colour change and heat given out, when a displacement reaction takes place.			
	Be able to write balanced chemical equations, ionic equations and half equations for displacement reactions			
Uses	Know the uses and applications of oxides of period 2 and 3 elements, based upon their properties, bonding and structure			
	Know the uses and applications of oxides, hydroxides, chlorides and sulfates of group 1 and 2 elements, and period 4 transition metals, based upon their properties, bonding and structure			