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| **Topic** | **Chemistry Student Checklist** | **R** | **A** | **G** |
| **Topic 1: Atomic structure and the periodic table** | State that everything is made of atoms, which are the smallest part of an element that can exist, and all elements are shown in the periodic table |  |  |  |
| Describe how compounds are made of different elements in fixed proportions, are formed by a chemical reaction and can only be separated into their constituent elements by a chemical reaction |  |  |  |
| State that elements and compounds are represented by symbols; and use chemical symbols and formulae to represent elements and compounds |  |  |  |
| Write word equations and balanced symbol equations for chemical reactions, including using appropriate state symbols |  |  |  |
| **HT ONLY: Write balanced half equations and ionic equations** |  |  |  |
| Describe a mixture as two or more elements or compounds that are not chemically combined, where the properties of each substance are unchanged |  |  |  |
| Name and describe the physical processes used to separate mixtures and suggest suitable separation techniques |  |  |  |
| Describe how the atomic model has changed over time due to new experimental evidence, including the discovery of the atom and Rutherford and Marsden's scattering experiments |  |  |  |
| State the relative charge of protons, neutrons and electrons and describe the overall charge of an atom |  |  |  |
| State the relative masses of protons, neutrons and electrons and describe the distribution of mass in an atom |  |  |  |
| Calculate the number of protons, neutrons and electrons in an atom when given its atomic number and mass number |  |  |  |
| Describe isotopes as atoms of the same element with different numbers of neutrons |  |  |  |
| Describe how electrons fill energy levels in atoms, and represent the electron structure of elements using diagrams and numbers |  |  |  |
| State that the elements in the periodic table are arranged by atomic (proton) number from left to right in rows, called periods |  |  |  |
| Describe how elements with similar properties are placed in columns, called groups, and elements in the same group in the periodic table have the same number of electrons in their outer shell |  |  |  |
| Explain that elements in the same group have similar properties and the reactions of elements are related to the arrangement of electrons in their atoms, use the periodic table to predict reactivity |  |  |  |
| Describe the early attempts to classify elements by arranging them in order of atomic weight, problems with this approach |  |  |  |
| Explain the creation and attributes of Mendeleev's periodic table |  |  |  |
| Identify metals and non-metals on the periodic table, compare and contrast their properties and explain that metals react to form positive ions and non-metals do not |  |  |  |
| Explain how the atomic structure of metals and non-metals relates to their position in the periodic table |  |  |  |
| Describe nobel gases (group 0) as being unreactive and explain that this is because they have a full outer shell of electrons |  |  |  |
| Describe the properties of noble gases, including boiling points, predict trends down the group andDescribe how their properties depend on the outer shell of electrons |  |  |  |
| Describe the reactivity and properties of group 1 alkali metals with reference to their electron arrangement and predict their reactions |  |  |  |
| Describe the properties of group 7 halogens and how their properties relate to their electron arrangement, including trends in molecular mass, melting and boiling points and reactivity |  |  |  |
| Describe the reactions of group 7 halogens with metals and non-metals, and explain how a more reactive halogen can displace a less reactive halogen in an aqueous solution of its salt |  |  |  |
| **Topic 2: Bonding, structure and the properties of matter** | Describe the three main types of bonds: ionic bonds, covalent bonds and metallic bonds in terms of electrostatic forces and the transfer or sharing of electrons |  |  |  |
| Describe how the ions produced by elements in some groups have the electronic structure of a noble gas and explain how the charge of an ion relates to its group number |  |  |  |
| Describe the structure of ionic compounds, including the electrostatic forces of attraction, and represent ionic compounds using dot and cross diagrams |  |  |  |
| Describe covalent bonds and identify different types of covalently bonded substances, such as small molecules, large molecules and substances with giant covalent structures |  |  |  |
| Represent covalent bonds between small molecules, repeating units of polymers and parts of giant covalent structures using diagrams, including dot and cross, ball and stick, and line diagrams |  |  |  |
| Describe the arrangement of atoms and electrons in metallic bonds and draw diagrams the bonding in metals |  |  |  |
| Name the three states of matter, identify them from a simple model and state which changes of state happen at melting and boiling points |  |  |  |
| Explain changes of state using particle theory and describe factors that affect the melting and boiling point of a substance |  |  |  |
| **HT ONLY: Discuss the limitations of particle theory** |  |  |  |
| Explain how the structure of ionic compounds affects their properties, including melting and boiling points and conduction of electricity |  |  |  |
| Explain how the structure of small molecules affects their properties |  |  |  |
| Explain how the structure of polymers affects their properties |  |  |  |
| Explain how the structure of giant covalent structures affects their properties |  |  |  |
| Explain how the structure of metals and alloys affects their properties, includingExplaining why they are good conductors |  |  |  |
| Explain the properties of graphite, diamond and graphene in terms of their structure and bonding |  |  |  |
| Describe the structure of fullerenes, and their uses, including Buckminsterfullerene and carbon nanotubes |  |  |  |
| **Topic 3: Quantitative chemistry** | State that mass is conserved and explain why, including describing balanced equations in terms of conservation of mass |  |  |  |
| Describe that the relative formula mass (Mr) of a compound is the sum of the relative atomic masses of the atoms in the compound and calculate the relative formula mass of a compound |  |  |  |
| Calculate the relative formula masses of reactants and products to prove that mass is conserved in a balanced chemical equation |  |  |  |
| Explain observed changes of mass during chemical reactions in non-enclosed systems using the particle model when given the balanced symbol equation |  |  |  |
| **HT ONLY: State that chemical amounts are measured in moles (mol) and explain what a mol is with reference to relative formula mass and Avogadro's constant** |  |  |  |
| **HT ONLY: Use the relative formula mass of a substance to calculate the number of moles in a given mass of the substance** |  |  |  |
| **HT ONLY: Calculate the masses of reactants and products when given a balanced symbol equation** |  |  |  |
| **HT ONLY: Use moles to write a balanced equation when given the masses of reactants and products** |  |  |  |
| **HT ONLY: Explain the effect of limiting the quantity of a reactant on the amount of products in terms of moles or masses in grams** |  |  |  |
| **Topic 4: Chemical changes** | State that metals react with oxygen to produce metal oxides and describe this process as an oxidation reaction, which is a gain of oxygen |  |  |  |
| Describe the arrangement of metals in the reactivity series, including carbon and hydrogen, and use the reactivity series to predict the outcome of displacement reactions |  |  |  |
| Explain how metals can be extracted from the compounds in which they are found in nature by reduction with carbon |  |  |  |
| Evaluate specific metal extraction processes when given appropriate information and identify which species are oxidised or reduced |  |  |  |
| **HT ONLY: Describe oxidation as the loss of electrons and reduction as the gain of electrons** |  |  |  |
| **HT ONLY: Write ionic equations for displacement reactions, and identify which species are oxidised and reduced from a symbol or half equation** |  |  |  |
| **HT ONLY: Explain in terms of gain or loss of electrons that the reactions between acids and some metals are redox reactions, and identify which species are oxidised and which are reduced** |  |  |  |
| Explain that acids can be neutralised by alkalis (soluble metal hydroxides), bases (insoluble metal hydroxides and metal oxides) and metal carbonates and list the products of each of these reactions |  |  |  |
| Predict the salt produced in a neutralisation reaction based on the acid used and the positive ions in the base, alkali or carbonate and use the formulae of common ions to deduce the formulae of the salt |  |  |  |
| Describe how soluble salts can be made from acids and how pure, dry samples of salts can be obtained |  |  |  |
| State that the pH scale is a measure of acidity and that a pH of 7 is neutral, a pH of less than 7 is acidic and a pH of greater than 7 is alkaline, and use a universal indicator to measure pH |  |  |  |
| State that acids produce hydrogen ions (H+) in aqueous solutions and alkalis produce hydroxide ions (OH–) and describe neutralisation reactions by using an |  |  |  |
| **HT ONLY: Use andExplain the terms dilute and concentrated (in terms of amount of substance) and weak and strong (in terms of the degree of ionisation) in relation to acids** |  |  |  |
| **HT ONLY: Explain how the concentration of an aqueous solution and the strength of an acid affects the pH of the solution and how pH is related to the hydrogen ion concentration of a solution** |  |  |  |
| Describe how ionic compounds can conduct electricity when dissolved in water andDescribe these solutions as electrolytes |  |  |  |
| Describe the process of electrolysis, including how positive and negative ions are attracted to the negative electrode (cathode) and positive electrode (anode) respectively |  |  |  |
| Describe the electrolysis of molten ionic compounds and predict the products at each electrode of the electrolysis of binary ionic compounds |  |  |  |
| Explain how metals are extracted from molten compounds using electrolysis and use the reactivity series toExplain why some metals are extracted with electrolysis instead of carbon |  |  |  |
| Describe the electrolysis of aqueous solutions and predict the products of the electrolysis of aqueous solutions containing single ionic compounds |  |  |  |
| **Describe the reactions at the electrodes during electrolysis as oxidation and reduction reactions and write balanced half equations for these reactions** |  |  |  |
| **Topic 5: Energy changes** | Describe how energy is transferred to or from the surroundings during a chemical reaction, how energy is transferred during exothermic and endothermic reactions |  |  |  |
| Describe activation energy as the minimum amount of energy that particles must have to react when they collide with each other |  |  |  |
| Interpret and draw reaction profiles of exothermic and endothermic reactions, including identifying the relative energies of reactants and products, the activation energy and the overall energy change |  |  |  |
| **HT ONLY: Explain how breaking bonds in reactants takes an input of energy and forming bonds in the products releases energy during a chemical reaction, calculate energy change** |  |  |  |
| **Topic 6: The rate and extent of chA4:A38emical change** | Calculate the rate of a chemical reaction over time, using either the quantity of reactant used or the quantity of product formed, measured in g/s, cm3/s or mol/s |  |  |  |
| Draw and interpret graphs showing the quantity of product formed or reactant used up against time and use the tangent to the graph as a measure of the rate of reaction |  |  |  |
| **HT ONLY: Calculate the gradient of a tangent to the curve on the graph of the quantity of product formed or reactant used against time and use this as a measure of the rate of reaction at a specific time** |  |  |  |
| Describe how factors affect the rate of a chemical reaction, including the concentration of reactants in solution, the pressure of reacting gases, the surface area of solid reactants, temperature and the presence of catalysts |  |  |  |
| Use collision theory to explain changes in the rate of reaction, including discussing activation energy |  |  |  |
| Describe the role of a catalyst in a chemical reaction, and state that enzymes are catalysts in biological systems |  |  |  |
| draw and interpret reaction profiles for catalysed reactions |  |  |  |
| Explain what a reversible reaction is, including how the direction can be changed, and represent it using symbols: A + B ⇌ C + D |  |  |  |
| Explain that, for reversible reactions, if a reaction is endothermic in one direction, it is exothermic in the other direction |  |  |  |
| Describe the state of dynamic equilibrium of a reaction as the point when the forward and reverse reactions occur at exactly the same rate |  |  |  |
| **HT ONLY: Explain that the position of equilibrium depends on the conditions of the reaction, and the equilibrium will change to counteract any changes to conditions** |  |  |  |
| **HT ONLY: Explain and predict the effect of a change in concentration of reactants or products, temperature, or pressure of gases on the equilibrium position of a reaction** |  |  |  |
| **Topic 7: Organic chemistry** | Describe what crude oil is and where it comes from, including the basic composition of crude oil and the general chemical formula for the homologous series of alkanes (CnH2n+2) |  |  |  |
| State the names of the first four members of the alkanes, and recognise substances as alkanes from their formulae |  |  |  |
| Describe the process of fractional distillation and state the names and uses of fuels that are produced from crude oil by fractional distillation |  |  |  |
| Describe trends in the properties of hydrocarbons, including boiling point, viscosity and flammability, and explain how their properties influence how they are used as fuels |  |  |  |
| Describe and write balanced chemical equations for the complete combustion of hydrocarbon fuels |  |  |  |
| Describe the process of cracking and state that the products of cracking include alkanes and alkenes, which are another type of hydrocarbon and more reactive than alkanes |  |  |  |
| **Topic 8: Chemical analysis** | Define a pure substance and identify pure substances and mixtures from data about melting and boiling points |  |  |  |
| Describe a formulation, and identify formulations given appropriate information |  |  |  |
| Describe chromatography, including the terms stationary phase and mobile phase, and identify pure substances using paper chromatography |  |  |  |
| Explain what the Rf value of a compound represents, how the Rf value differs in different solvents, and interpret and determine Rf values from chromatograms |  |  |  |
| Explain how to test for the presence of hydrogen, oxygen, carbon dioxide and chlorine |  |  |  |
| **Topic 9: Chemistry of the atmosphere** | Describe the makeup of Earth's atmosphere using percentages, fractions or ratios, including nitrogen, oxygen and other gases, such as carbon dioxide, water vapour and noble gases |  |  |  |
| Describe how early intense volcanic activity may have helped form the early atmosphere and water vapour that condensed to form oceans, including the build up of nitrogen from the volcanoes |  |  |  |
| Explain how, at the beginning of Earth's existence, oxygen was produced by photosynthesis and use the word and chemical equation for photosynthesis |  |  |  |
| State the approximate time in Earth's history when algae started producing oxygen and describe the effects of a gradually increasing oxygen level |  |  |  |
| Explain ways that atmospheric carbon dioxide levels decreased, including photosynthesis, the formation of sedimentary rocks and the creation of crude oil from the remains of plankton |  |  |  |
| Name some greenhouse gases and describe how they cause an increase in Earth's temperature |  |  |  |
| List some human activities that produce greenhouse gases |  |  |  |
| Evaluate arguments for and against the idea that human activities cause a rise in temperature that results in global climate change |  |  |  |
| State some potential side effects of global climate change, including discussing scale, risk and environmental implications |  |  |  |
| Define a carbon footprint as the total amount of carbon dioxide and other greenhouse gases emitted over the life cycle of a product, service or event and list some actions that could reduce the carbon footprint |  |  |  |
| Describe the combustion of fuels as a major source of atmospheric pollutants and name the different gases that are released when a fuel is burned |  |  |  |
| Describe the properties and effects of carbon monoxide, sulfer dioxide and particulates in the atmosphere |  |  |  |
| **Topic 10: Using resources** | Give some examples of natural resources and describe how they are used by humans |  |  |  |
| Explain that Earth's resources are finite, and they are processed to provide energy and materials for consumption, and give examples of finite and renewable resources |  |  |  |
| Explain what sustainable development is and discuss the role chemistry plays in sustainable development, including improving agricultural and industrial processes |  |  |  |
| Discuss the importance of water quality for human life, including defining potable (drinkable) water |  |  |  |
| Describe methods to produce potable water, including desalination of salty water or sea water and the potential problems of desalination |  |  |  |
| Describe waste water as a product of urban lifestyles and industrial processes that includes organic matter, harmful microbes and harmful chemicals |  |  |  |
| Describe the process of sewage treatment and compare the ease of obtaining potable water from waste water as opposed to ground or salt water |  |  |  |
| **HT ONLY: Name and describe alternative biological methods for extracting metals, including phytomining and bioleaching** |  |  |  |
| **HT ONLY: Evaluate alternative methods for extracting metals** |  |  |  |
| Describe, carry out and interpret a simple comparative LCA of materials or products |  |  |  |
| Discuss the advantages and disadvantages of LCAs, including the difficulty in quantifying pollutant effects and the misuse or misinterpretation of abbreviated LCAs |  |  |  |
| Discuss how to reduce the consumption of raw resources by reducing use, reusing, and recycling products and explain how reusing and recycling reduces energy use |  |  |  |