3rd Year Chemistry

| Spec ref. | Summary of the specification content | Learning outcomes *What most candidates should be able to do* | Suggested timing (hours) | Opportunities to develop Scientific Communication skills | Opportunities to develop and apply practical and enquiry skills | Self/peer assessment opportunities and resources *Reference to past questions that indicate success* | Key pieces of assessed work |
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| 4.2.1.1 | There are three types of strong chemical bonds: ionic, covalent and metallic. For ionic bonding the particles are oppositely charged ions. For covalent bonding the particles are atoms which share pairs of electrons. For metallic bonding the particles are atoms which share delocalised electrons.<br>Ionic bonding occurs in compounds formed from metals combined with non-metals.<br>Covalent bonding occurs in non-metallic elements and in compounds of non-metals.<br>Metallic bonding occurs in metallic elements and alloys. | Students should be able to explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons. | 1 | Define 'electrostatic forces of attraction'.<br><br>Extended writing: describe why atoms bond in order to obtain a noble gas configuration/full outer level of electrons.<br><br>Describe/draw the structure of common atoms and suggest how they could bond to obtain a full outer level of electrons. | Demo the formation of sodium chloride in a fume cupboard. | | |
| 4.2.1.2 | When a metal atom reacts with a non-metal atom, electrons in the outer shell of the metal atom are transferred. Metal atoms lose electrons to become positively charged ions. Non-metal atoms gain electrons to become negatively charged | Students should be able to:<br>• draw dot and cross diagrams for ionic compounds formed by metals in | 0.5 | Tabulate common atoms and state the charges of the ions formed.<br><br>Grade 9: explain an example of ionic bonding including | Use magnesium ribbon to produce magnesium oxide. Draw the dot and cross diagram for this reaction. | Exampro user guide PowerPoint<br><br>Video clips:<br>BBC Bitesize Ionic compounds and the periodic table | |

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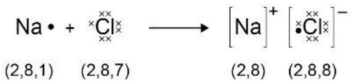
| | ions. The ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 have the electronic structure of a noble gas (Group 0).<br>The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram, eg for sodium chloride:<br><br>The charge on the ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 relates to the group number of the element in the periodic table. | Groups 1 and 2 with non-metals in Groups 6 and 7<br>• work out the charge on the ions of metals and non-metals from the group number of the element, limited to the metals in Groups 1 and 2, and non-metals in Groups 6 and 7.<br><br>WS 1.2<br><br>Students should be able to translate data between diagrammatic and numeric forms (MS 4a).<br><br>MS 5b | | detail on electron transfer, group numbers of the atoms involved and the use of correct terms, eg cation and anion. | | YouTube: What are ions?<br><br>YouTube: What are ionic bonds? | |
| 4.2.1.3 | An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act | Students should be familiar with the structure of sodium chloride but do **not** need to know the structures of | 1 | Extended writing: describe the bonding in the sodium chloride lattice using the correct terms, eg electrostatic forces of attraction. | Model the sodium chloride lattice using molecular model kits. | | Past paper question 3.1, 3.2, 3.6 specimen paper 1 set1 |

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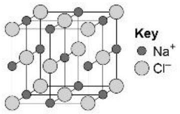
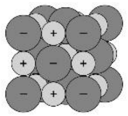
| | in all directions in the lattice and this is called ionic bonding.<br><br>The structure of sodium chloride can be represented in the following forms:<br> | other ionic compounds.<br><br>Students should be able to:<br>• deduce that a compound is ionic from a diagram of its structure in one of the specified forms<br>• describe the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent a giant ionic structure<br>• work out the empirical formula of an ionic compound from a given model or diagram that shows the ions in the structure.<br>WS 1.2 | | | | | | |

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| | | Students should be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects. MS 4a, 1a, 1c. | | | | | | |
| 4.2.1.4 | When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong.<br>Covalently bonded substances may consist of small molecules.<br>Some covalently bonded substances have very large molecules, such as polymers.<br>Some covalently bonded substances have giant covalent structures, such as diamond and silicon dioxide.<br>The covalent bonds in molecules and giant structures can be represented in the following forms: | Students should be able to:<br>• recognise substances as small molecules, polymers or giant structures from diagrams showing their bonding<br>• recognise common substances that consist of small molecules from their chemical formula.<br>• draw dot and cross diagrams for the molecules of hydrogen, chlorine, oxygen, nitrogen, | 1 | Extended writing: describe the difference between simple covalent substances and giant covalent substances.<br><br>Grade 9: explain an example of covalent bonding including detail on electron transfer, group numbers of the atoms involved and the use of correct terminology. | Demo the formation of hydrogen chloride. Draw the dot and cross diagram for this reaction.<br><br>Model simple covalent substance using molecular model kits.<br><br>Demo giant covalent structures using molecular model kits. | Video clip:<br>BBC Bitesize Covalent bonding and the periodic table | Past paper question 3.3, 3.4, 3.5 specimen paper 1 set1 | |

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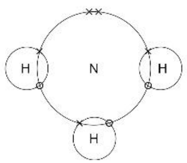
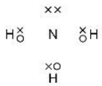
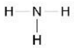
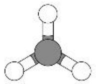
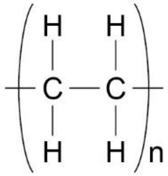
| | **For ammonia ($NH_3$)**<br><br>and/or<br><br>and/or<br><br>and/or<br><br>Polymers can be represented in the form:<br><br>poly(ethene)<br>where n is a large number. | hydrogen chloride, water, ammonia and methane<br>• represent the covalent bonds in small molecules, in the repeating units of polymers and in part of giant covalent structures, using a line to represent a single bond<br>• describe the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent molecules or giant structures<br>• deduce the molecular formula of a substance from a given model or diagram in these forms showing the | | | | | |

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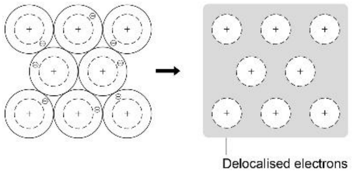
| | | atoms and bonds in the molecule.<br>WS 1.2<br><br>Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.MS 5b | | | | | |
| 4.2.1.5 | Metals consist of giant structures of atoms arranged in a regular pattern.<br>The electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure.<br>The sharing of delocalised electrons gives rise to strong metallic bonds. The bonding in metals may be represented in the following form:<br> | WS 1.2<br>Students should be able to:<br>• recognise substances as giant metallic structures from diagrams showing their bonding<br>• visualise and represent 2D and 3D forms including two dimensional representations of 3D objects. MS 5b | 0.5 | Define 'delocalised electrons'. | Use copper wire and silver nitrate solution to grow silver crystals. | Video clips:<br>BBC Bitesize The atomic structure of metals<br><br>YouTube: What are metallic bonds? | |
| 4.2.2.1 | The three states of matter are solid, liquid and gas. Melting and freezing take place at the melting point, boiling and | Students should be able to:<br>• predict the states of | 1 | Extended writing: describe the properties of matter | | Video clips:<br>BBC Bitesize Particle models of solids, liquids and gases | |

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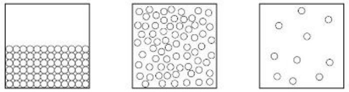
| | condensing take place at the boiling point.<br>The three states of matter can be represented by a simple model. In this model, particles are represented by small solid spheres. Particle theory can help to explain melting, boiling, freezing and condensing.<br><br><br>Solid Liquid Gas<br><br>The amount of energy needed to change state from solid to liquid and from liquid to gas depends on the strength of the forces between the particles of the substance. The nature of the particles involved depends on the type of bonding and the structure of the substance. The stronger the forces between the particles, the higher the melting point and boiling point of the substance.<br>(Higher Tier only) Limitations of the simple model above include that in the model there are no forces, that all particles are represented as spheres and that the spheres are solid. | substances at different temperatures given appropriate data<br>• explain the different temperatures at which changes of state occur in terms of energy transfers and types of bonding<br>• recognise that atoms themselves do not have the bulk properties of materials<br>• (Higher Tier only) explain the limitations of the particle theory in relation to changes of state when particles are represented by solid spheres which have no forces between them. | | in a solid, liquid and gas.<br><br>Define melting point and boiling point.<br><br>Grade 9: explain the differences in changes of state in terms of intermolecular forces of attraction between a short molecule ie methane and a longer molecule ie pentane. | | BBC Bitesize Changes of state<br><br>YouTube: States of matter | |

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| | | WS 1.2<br><br>Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects. MS 5b | | | | | |
| 4.2.2.2 | In chemical equations, the three states of matter are shown as (s), (l) and (g), with (aq) for aqueous solutions. | Include appropriate state symbols in chemical equations for the reactions in this specification. | 0.5 | Describe balanced symbol equations including the states of matter. | | | |
| 4.2.2.3 | Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces of attraction in all directions between oppositely charged ions.<br>These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.<br>When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and so charge can flow. | Knowledge of the structures of specific ionic compounds other than sodium chloride is not required. | 1 | Extended writing: describe the electrical conductivity of ionic substances.<br><br>Extended writing: explain why solid ionic substances do not conduct electricity but dissolved or molten ionic substances do conduct electricity.<br><br>Grade 9: explain how ionic substances dissolve in water. | Research some uses of ionic substances. Extension: make links between the uses of ionic substances, their properties and structure.<br><br>Practically test the conductivity of ionic compounds, eg sodium chloride and potassium chloride. | Video clip<br>YouTube: Ionic compounds and their properties | |

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| | | | | Extended writing: explain why sodium chloride is difficult to melt. | | | |
| 4.2.2.4 | Substances that consist of small molecules are usually gases or liquids that have relatively low melting points and boiling points.<br>These substances have only weak forces between the molecules (intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.<br>The intermolecular forces increase with the size of the molecules, so larger molecules have higher melting and boiling points.<br>These substances do not conduct electricity because the molecules do not have an overall electric charge. | Students should be able to use the idea that intermolecular forces are weak compared with covalent bonds to explain the bulk properties of molecular substances. | 0.5 | Extended writing: describe melting points and boiling points of covalent substances.<br><br>Extended writing: explain why the melting point and boiling point increases as the size of the molecule does in terms of intermolecular forces.<br><br>Extended writing: explain why covalent substances do not conduct electricity.<br><br>Grade 9: explain why pure water does not conduct electricity but tap water does conduct electricity. | Research some uses of covalent substances.<br><br>Extension: make links between the uses of covalent substances, their properties and structure.<br><br>Practically test the conductivity of simple covalent substances using ethanol and solid wax pieces. | Video clip<br>YouTube: Properties of covalent compounds | |
| 4.2.2.5 | Polymers have very large molecules. The atoms in the polymer molecules are linked to other atoms by strong covalent bonds. The intermolecular forces between polymer | Students should be able to recognise polymers from diagrams showing their bonding. | 1 | Extended writing: explain how ethene polymerises. | Model polymers.<br><br>Make a polymer from cornstarch. | Video clips:<br>BBC Bitesize The plastic revolution<br><br>BBC Bitesize The uses of polymers | |

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| | molecules are relatively strong and so these substances are solids at room temperature. | | | | Investigate the properties of plastic bags. | YouTube: [Polymerisation of propene and chloroethene] | |
| 4.2.2.6 | Substances that consist of giant covalent structures are solids with very high melting points. All of the atoms in these structures are linked to other atoms by strong covalent bonds. These bonds must be overcome to melt or boil these substances. Diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures. | Students should be able to recognise giant covalent structures from diagrams showing their bonding and structure.<br>WS 1.2<br>MS 5b | 0.5 | Extended writing: describe the structure of diamond, silicon dioxide and graphite.<br><br>Extended writing: explain how covalent substances boil. | Research some uses of covalent substances.<br><br>Extension: make links between the uses of covalent substances, their properties and structure. | | |
| 4.2.2.7 | Metals have giant structures of atoms with strong metallic bonding. This means that most metals have high melting and boiling points.<br><br>In pure metals, atoms are arranged in layers, which allows metals to be bent and shaped. Pure metals are too soft for many uses and so are mixed with other metals to make alloys which are harder.. | Explain why alloys are harder than pure metals in terms of distortion of the layers of atoms in the structure of a pure metal.<br>WS 1.2 | 1 | Extended writing: describe melting points and boiling points of metallic substances.<br><br>Extended writing: explain why the melting point and boiling point of metallic substances are high.<br><br>Extended writing: describe the structure of metal alloys. | Research some uses of metallic substances.<br><br>Extension: make links between the uses of metal substances, their properties and structure.<br><br>Research some uses of metal alloys.<br><br>Extension: make links between the uses of metal | Video clips:<br>[BBC Bitesize The properties and uses of metals]<br><br>[BBC Bitesize Bronze – the first alloy] | |

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| | | | | | alloys, their properties and structure. | | |
| 4.2.2.8 | Metals are good conductors of electricity because the delocalised electrons in the metal carry electrical charge through the metal. Metals are good conductors of thermal energy because energy is transferred by the delocalised electrons. | | 0.5 | Extended writing: explain why metallic substances conduct electricity. | | | |
| 4.2.3.1 | In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard, has a very high melting point and does not conduct electricity. | Explain the properties of diamond in terms of its structure and bonding.<br>WS 1.2<br>Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.<br>MS 5b | 1 | Extended writing: link the properties of diamond to the structure. | Research the properties of diamond.<br><br>Model the structure of diamond using model kits. | Video clips:<br>BBC Bitesize Properties of diamonds<br><br>YouTube: Structure of diamond and graphite | |
| 4.2.3.2 | In graphite, each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings which have no covalent bonds between the layers.<br>In graphite, one electron from each carbon atom is delocalised. | Explain the properties of graphite in terms of its structure and bonding.<br><br>Know that graphite is similar to metals in that | 0.5 | Extended writing: link the properties of graphite to the structure.<br><br>Extended writing: explain why graphite conducts electricity. | Research the properties of graphite.<br><br>Model the structure of graphite using model kits. | Video clip:<br>BBC Bitesize Properties and structure of graphite | |

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| | | it has delocalised electrons.<br>WS 1.2 | | | | | |
| 4.2.3.3 | Graphene is a single layer of graphite and has properties that make it useful in electronics and composites. Fullerenes are molecules of carbon atoms with hollow shapes. The structure of fullerenes is based on hexagonal rings of carbon atoms but they may also contain rings with five or seven carbon atoms. The first fullerene to be discovered was Buckminsterfullerene ($C_{60}$) which has a spherical shape.<br><br>Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios. Their properties make them useful for nanotechnology, electronics and materials. | Recognise graphene and fullerenes from diagrams and descriptions of their bonding and structure.<br><br>Give examples of the uses of fullerenes, including carbon nanotubes.<br><br>Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects.<br>WS 1.2, 1.4<br>MS 5b | 0.5 | Extended writing: link the properties of graphene to the structure.<br><br>Extended writing: describe the history of fullerenes. | Research the properties of graphene.<br><br>Research uses of fullerenes. | Video clips:<br>BBC Bitesize Discovery and uses of graphene<br><br>YouTube: Bucky Balls, Graphene and Nano Tubes | |
| 4.2.4.1 | Nanoscience refers to structures that are 1–100 nm in size, of the order of a few hundred atoms. Nanoparticles are smaller than fine particles ($PM_{2.5}$), which have diameters between 100 and 2500 nm ($1 \times 10^{-7}$ m and $2.5 \times 10^{-6}$ m). Coarse particles ($PM_{10}$) have diameters between $1 \times 10^{-5}$ m and 2.5 x | Students should be able to compare 'nano' dimensions to typical dimensions of atoms and molecules.<br>WS 1.2, 1.4, 4.1, 4.2, 4.3, 4.4, 4.5 | 0.5 | Extended writing: describe the history of nanoscience. | | Video clip<br>YouTube: What is nanoscience? | Past paper question 6 specimen paper 1 set 2 |

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| | $10^{-6}$ m. Coarse particles are often referred to as dust.<br>As the side of cube decreases by a factor of 10 the surface area to volume ratio increases by a factor of 10.<br>Nanoparticles may have properties different from those for the same materials in bulk because of their high surface area to volume ratio. It may also mean that smaller quantities are needed to be effective than for materials with normal particle sizes. | MS 1b, 1c, 1d, 2h, 5c | | | | | |
| 4.2.4.2 | Nanoparticles have many applications in medicine, in electronics, in cosmetics and sun creams, as deodorants, and as catalysts. New applications for nanoparticulate materials are an important area of research. | Consider some of the applications of these nanoparticulate materials.<br><br>Students do **not** need to know specific examples or properties other than those specified.<br><br>Given appropriate information, evaluate the use of nanoparticles | 0.5 | Extended writing: link the uses of nanoparticles to their properties.<br><br>Extended writing: evaluate the use of nanoparticles in applications, eg sun cream. | Research uses and properties of nanoparticles. | Video clip<br>YouTube: Bucky Balls, Graphene and Nano Tubes | Question booklet Atomic structure and bonding 4<br><br>Extension; Question booklet Atomic structure and bonding 1,2,3 5,6,7,8,9<br><br>TEST |

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| | | for a specified purpose<br><br>Explain that there are possible risks associated with the use of nanoparticles.<br>WS 1.3, 1.4, 1.5 | | | | | | |