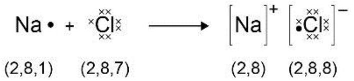
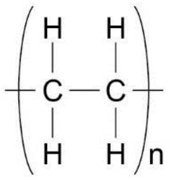
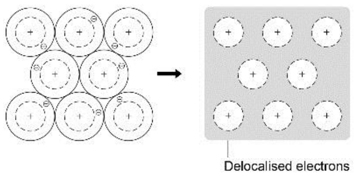
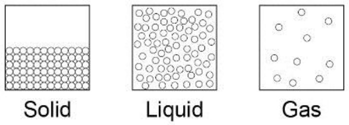
	Chemistry 4.2 Bonding	NEED TO KNOW	REVISION
4.2.1.1	There are three types of strong chemical bonds: ionic, covalent and metallic. For ionic bonding the particles are oppositely charged ions. For covalent bonding the particles are atoms which share pairs of electrons. For metallic bonding the particles are atoms which share delocalised electrons. Ionic bonding occurs in compounds formed from metals combined with non-metals. Covalent bonding occurs in non-metallic elements and in compounds of non-metals. Metallic bonding occurs in metallic elements and alloys.	Explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons.	
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 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). The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram, eg for sodium chloride:  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.	Draw dot and cross diagrams for ionic compounds formed by metals in Groups 1 and 2 with non-metals in Groups 6 and 7 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. Be able to translate data between diagrammatic and numeric forms (MS 4a).	
4.2.1.3	Students should be able to: • draw dot and cross diagrams for ionic compounds formed by metals in Groups 1 and 2 with non-metals in Groups 6 and 7 • 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. Students should be able to translate data between diagrammatic and numeric forms	Be familiar with the structure of sodium chloride but do **not** need to know the structures of other ionic compounds. Be able to: • deduce that a compound is ionic from a diagram of its structure in one of the specified forms • describe the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent a giant ionic structure • work out the empirical formula of an ionic compound from a given model or diagram that shows the ions in the structure. Be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.	

4.2.1.4	When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Covalently bonded substances may consist of small molecules, such as H_2, Cl_2, O_2, N_2, HCl, H_2O, NH_3 and CH_4. Some covalently bonded substances have very large molecules, such as polymers. Some covalently bonded substances have giant covalent structures, such as diamond and silicon dioxide. The covalent bonds in molecules and giant structures can be represented in the following forms: Polymers can be represented in the form:  poly(ethene) where n is a large number.	• recognise substances as small molecules, polymers or giant structures from diagrams showing their bonding • draw dot and cross diagrams for the molecules H_2, Cl_2, O_2, N_2, HCl, H_2O, NH_3 and CH_4 • 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 • describe the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent molecules or giant structures • deduce the molecular formula of a substance from a given model or diagram in these forms showing the atoms and bonds in the molecule. Should be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects	
4.2.1.5	Metals consist of giant structures of atoms arranged in a regular pattern. The electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure. The sharing of delocalised electrons gives rise to strong metallic bonds. The bonding in metals may be represented in the following form:  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.	• recognise substances as giant metallic structures from diagrams showing their bonding • visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.	

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.	Be able to describe and explain why metals are able to conduct eletricity	
4.2.2.1 4.2.2.2	The three states of matter are solid, liquid and gas. Melting and freezing take place at the melting point, boiling and condensing take place at the boiling point. 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.  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. *<u>(HT only) limitations of the simple model include that there are no forces between the spheres, that all particles are represented as spheres and that the spheres are solid.</u>* In chemical equations, the three states of matter are shown as (s), (l) and (g), with (aq) for aqueous solutions.	• predict the states of substances at different temperatures given appropriate data • explain the different temperatures at which changes of state occur in terms of energy transfers and types of bonding • recognise that atoms themselves do not have the bulk properties of materials • 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. Be able to relate the size and scale of atoms to objects in the physical world. Be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects. Be able to include appropriate state symbols in chemical equations for the reactions in this specification.	
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. These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds. 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.	
4.2.2.4	Substances that consist of small molecules are usually gases or liquids that have relatively low melting points and boiling points. These substances have only weak forces between the molecules	Be able to use the idea that intermolecular forces are weak compared with covalent bonds to explain the bulk properties of molecular substances. 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.	

	(Intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils. The intermolecular forces increase with the size of the molecules, so larger molecules have higher melting and boiling points. These substances do not conduct electricity because the molecules do not have an overall electric charge.		
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 molecules are relatively strong and so these substances are solids at room temperature.	Be able to recognise polymers from diagrams showing their bonding.	
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.	
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. In metals, the layers of atoms are able to slide over each other. This means metals can be bent and shaped. Most metals in everyday use are alloys. Pure copper, gold, iron and aluminium are too soft for many uses and so are mixed with other metals to make alloys. The different sizes of atoms in an alloy distort the layers in the structure, making it more difficult for them to slide over each other, so alloys are harder than pure metals.	Students should be able to explain why an alloy of a metal is harder than the pure metal.	
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.	Be able to explain the properties of diamond in terms of its structure and bonding. Be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.	

4.2.3.2	In graphite, each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings and so graphite has a high melting point. The layers are free to slide over each other because there are no covalent bonds between the layers and so graphite is soft and slippery. In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct thermal energy and electricity.	Students should be able to explain the properties of graphite in terms of its structure and bonding. Students should know that graphite is similar to metals in that it has delocalised electrons.	
4.2.3.3	Graphene is a single layer of graphite and so is one atom thick. 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. Carbon nanotubes are cylindrical fullerenes. They have high tensile strength, high electrical conductivity and high thermal conductivity. Fullerenes can be used for drug delivery into the body, as lubricants, as catalysts and carbon nanotubes can be used for reinforcing materials, eg in tennis rackets.	Be able to recognise graphene/ fullerenes from diagrams Be able to explain why graphene is strong and able to conduct	