AQA Chemistry GCSE Student Progress

Unit 4.2 - Bonding, Structure and the Properties of Matter

4.2.1. Chemical Bonds, Ionic, Covalent and Metallic

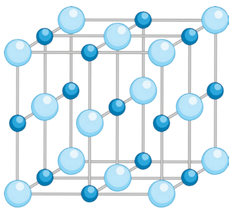
4.2.1.1. Chemical Bonds

a	I know that there are three types of strong chemical bonds: ionic, covalent and metallic.			
b	I know that for ionic bonding the particles are oppositely charged ions and that it occurs in compounds formed from metals combined with non-metals.			
c	I know that, for covalent bonding, the particles are atoms which share pairs of electrons and that it occurs in most non-metallic elements and in compounds of non-metals.			
d	I know that for metallic bonding the particles are atoms which share delocalised electrons and that it occurs in metallic elements and alloys.			
e	I can explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons.			

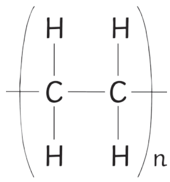
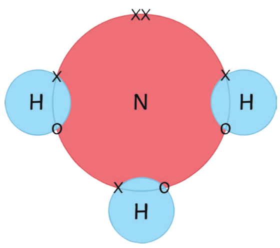
4.2.1.2. Ionic Bonding

a	I know that 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.			
b	I know that 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).			
c	I can draw dot and cross diagrams for ionic compounds formed by metals in Groups 1 and 2 with non -metals in Groups 6 and 7, e.g. for sodium chloride.			
d	I can 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).			

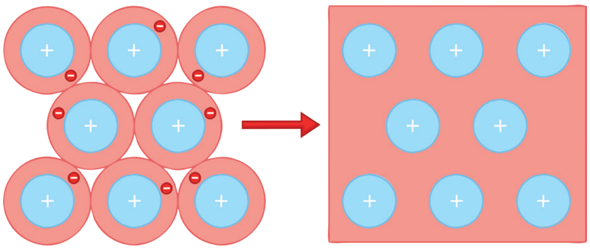
4.2.1.3. Ionic Compounds

a	I know that an ionic compound is a giant structure of ions.			
b	I know that ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions, that these forces act in all directions in the lattice, and that this is called ionic bonding.			
c	I know that the structure of sodium chloride can be represented in the following form: 			
d	I can deduce that a compound is ionic from a diagram of its structure.			
e	I can describe the limitations of using dot and cross, ball and stick, two and three-dimensional diagrams to represent a giant ionic structure			
f	I can work out the empirical formula of an ionic compound from a given model or diagram that shows the ions in the structure.			

4.2.1.4. Covalent Bonding

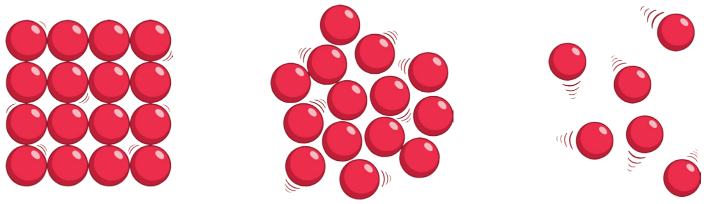
a	I know that atoms form covalent bonds when they share pairs of electrons. These bonds between atoms are strong.			
b	I know that covalently bonded substances may consist of small molecules.			
c	I can recognise common substances that consist of small molecules from their chemical formula.			
d	I know that some covalently bonded substances have very large molecules, such as polymers.			
e	I know that polymers can be represented in the following form where n is a large number:  Poly(ethene)			
f	I know that some covalently bonded substances have giant covalent structures, such as diamond and silicon dioxide.			
g	I know that the covalent bonds in molecules and giant structures can be represented in the following form: 			
h	I can draw dot and cross diagrams for the molecules of hydrogen, chlorine, oxygen, nitrogen, hydrogen chloride, water, ammonia and methane.			
i	I can 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.			
j	I can describe the limitations of using dot and cross, ball and stick, two and three-dimensional diagrams to represent molecules or giant structures.			
k	I can deduce the molecular formula of a substance from a given model or diagram in these forms showing the atoms and bonds in the molecule.			

4.2.1.5. Metallic Bonding

a	I know that metals consist of giant structures of atoms arranged in a regular pattern.			
b	I know that the electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure.			
c	I know that the sharing of delocalised electrons gives rise to strong metallic bonds.			
d	I know that the bonding in metals may be represented in the following form: 			
e	I can recognise substances as metallic giant structures from diagrams showing their bonding.			

4.2.2. How Bonding and Structure Are Related to the Properties of Structures

4.2.2.1. The Three States of Matter

a	I know that the three states of matter are: solid, liquid and gas.			
b	I know that melting and freezing take place at the melting point, while boiling and condensing take place at the boiling point.			
c	I know that 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. 			
d	I can discuss the limitations of the simple particle model above including; that in the model there are no forces, that all particles are represented as spheres and that the spheres are solid (HT only).			
e	I know that 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 stronger the forces between the particles the higher the melting point and boiling point of the substance.			
f	I can predict the states of substances at different temperatures given appropriate data.			
g	I can explain the different temperatures at which changes of state occur in terms of energy transfers and types of bonding.			
h	I can recognise that atoms themselves do not have the bulk properties of materials.			
i	I can explain the limitations of the particle theory in relation to changes of state when particles are represented by solid inelastic spheres which have no forces between them (HT only).			

4.2.2.2. State Symbols

a	I know that, in chemical equations, the three states of matter are shown as (s), (l) and (g), with (aq) for aqueous solutions.			

4.2.2.3. Properties of Ionic Compounds

a	I know that ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces of attraction in all directions between oppositely charged ions.			
b	I know that ionic compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.			
c	I know that, when melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and so charge can flow.			

4.2.2.4. Properties of Small Molecules

a	I know that substances consisting of small molecules are usually gases or liquids that have relatively low melting points and boiling points.			
b	I know that substances consisting of small molecules have only weak forces between the molecules (intermolecular forces) and that it is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.			
c	I know that intermolecular forces increase with the size of the molecules, so substances that consist of larger molecules have higher melting and boiling points.			
d	I know that substances consisting of small molecules do not conduct electricity because the molecules do not have an overall electric charge.			
e	I can explain the bulk properties of molecular substances using the idea that intermolecular forces are weak compared with covalent bonds.			
4.2.2.5. Polymers				
a	I know that polymers have very large molecules and that the atoms in the polymer molecules are linked to other atoms by strong covalent bonds.			
b	I know that the intermolecular forces between polymer molecules are relatively strong and so these substances are solids at room temperature.			
c	I can recognise polymers from diagrams showing their bonding and structure.			
4.2.2.6. Giant Covalent Structures				
a	I know that substances consisting of giant covalent structures are solids with very high melting points.			
b	I know that all of the atoms in giant covalent structures are linked to other atoms by strong covalent bonds and that these bonds must be overcome to melt or boil these substances.			
c	I know that diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures.			
d	I can recognise giant covalent structures from diagrams showing their bonding and structure.			
4.2.2.7. Properties of Metals and Alloys				
a	I know that metals have giant structures of atoms with strong metallic bonding, which means that most metals have high melting and boiling points.			
b	I know that, in pure metals, atoms are arranged in layers which allows metals to be bent and shaped.			
c	I know that pure metals are too soft for many uses and so are mixed with other metals to make alloys which are harder.			
d	I can explain why alloys are harder than pure metals in terms of distortion of the layers of atoms in the structure of a pure metal.			

4.2.2.8. Metals as Conductors

a	I know that metals are good conductors of electricity because the delocalised electrons in the metal carry electrical charge through the metal.			
b	I know that metals are good conductors of thermal energy because energy is transferred by the delocalised electrons.			

4.2.3. Structure and Bonding of Carbon

4.2.3.1. Diamond

a	I know that, 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.			
b	I can explain the properties of diamond in terms of its structure and bonding.			

4.2.3.2. Graphite

a	I know that, 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.			
b	I know that, in graphite, one electron from each carbon atom is delocalised.			
c	I know that graphite is similar to metals in that it has delocalised electrons.			
d	I can explain the properties of graphite in terms of its structure and bonding.			

4.2.3.3. Graphene and Fullerenes

a	I know that graphene is a single layer of graphite and has properties that make it useful in electronics and composites.			
b	I can explain the properties of graphene in terms of its structure and bonding.			
c	I know that 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.			
d	I know that the first fullerene to be discovered was Buckminsterfullerene (C_{60}), which has a spherical shape.			
e	I know that carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios and that their properties make them useful for nanotechnology, electronics and materials.			
f	I can recognise graphene and fullerenes from diagrams and descriptions of their bonding and structure.			
g	I can give examples of the uses of fullerenes, including carbon nanotubes.			

4.2.4. Bulk and Surface Properties of Matter including Nanoparticles (Chemistry Only)

4.2.4.1. Sizes of Particles and their Properties (Chemistry Only)

a	I know that nanoscience refers to structures that are 1–100 nm in size, of the order of a few hundred atoms.			
b	I know that nanoparticles, are smaller than fine particles (PM2.5), which have diameters between 100 and 2500 nm (1 x 10-7 m and 2.5 x 10-6 m).			
c	I know that coarse particles (PM10) have diameters between 1 x 10-5 m and 2.5 x 10-6 m and that they are often referred to as dust.			
d	I know that as the side of cube decreases by a factor of 10 the surface area to volume ratio increases by a factor of 10.			
e	I know that nanoparticles may have properties different from those for the same materials in bulk because of their high surface area to volume ratio.			
f	I know that smaller quantities of nanoparticles may be needed to be effective, than for materials with normal particle sizes.			
g	I can compare 'nano' dimensions to typical dimensions of atoms and molecules.			

4.2.4.2. Uses of Nanoparticles (Chemistry Only)

a	I know that nanoparticles have many applications in medicine, in electronics, in cosmetics and sun creams, as deodorants, and as catalysts.			
b	I know that new applications for nanoparticulate materials are an important area of research.			
c	I can describe the advantages and disadvantages of the applications of nanoparticulate materials.			
d	I can evaluate the use of nanoparticles for a specified purpose.			
e	I can explain that there are possible risks associated with the use of nanoparticles.			