# Scheme of work

## Combined Science: Trilogy - Foundation

## Chemistry – Bonding, structure and the properties of matter

This resource provides guidance for teaching the Bonding, structure, and the properties of matter topic from our new GCSE Combined Science: Trilogy specification (8464). It has been updated from the draft version to reflect the changes made in the accredited specification. These changes are also reflected in the learning outcomes with some additions to the resources.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 5.2 Bonding, structure and the properties of matter

#### 5.2.1 Chemical bonds, ionic, covalent and metallic

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most students 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* |
| --- | --- | --- | --- | --- | --- | --- |
| 5.2.1.1 | 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. | Be able to explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons. | 1 | Recall the structure of an atom.  Define an ion and valence electrons.  Define ‘electrostatic forces’ of attraction.  Describe the ions formed by metals and non-metals. | Use large cardboard circle templates for atoms, with an inner circle for a nucleus, and at least 3 energy levels.  Pupils cut out a nucleus, and add the symbol and proton number. Add electrons using split pins onto the correct energy level.  Draw an electron dot diagram of the atom. Remove the valence electrons (or add more) to get to the nearest full energy level.  Draw an electron dot diagram of the ion. Indicate whether the ion is positive or negative. | [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 5.2.1.2 | 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.  WS 1.2  Translate data between diagrammatic and numeric forms  MS 4a, 5b | 1 | Draw a dot and cross diagram for ionic compounds formed by magnesium and oxygen.  Draw a flow diagram to explain the reaction of magnesium and oxygen into magnesium oxide in terms of ions and electron structure.  Use a periodic table to work out the charge on the ions from Groups 1, 2, 6 and 7. | Use magnesium ribbon to produce magnesium oxide. | Video clips:  [BBC Bitesize Ionic compounds and the periodic table](http://www.bbc.co.uk/education/clips/zx2r87h)  YouTube: [What are ions?](https://www.youtube.com/watch?v=900dXBWgx3Y)  YouTube: [What are ionic bonds?](https://www.youtube.com/watch?v=zpaHPXVR8WU) |
| 5.2.1.3 | 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 in all directions in the lattice and this is called ionic bonding.  The structure of sodium chloride can be represented in the following forms: | Be familiar with the structure of sodium chloride but do **not** need to know the structures of other ionic compounds.  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.  WS 1.2  Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.  MS 4a, 1a, 1c. | 1 | Describe an ionic compound.  Draw a diagram of sodium chloride.  Draw a dot and cross diagram for the ionic compound formed by sodium and chlorine.  Ask students to work out the empirical formula of ionic compounds from various models of elements with their valence electrons. | Demo the formation of sodium chloride in a fume cupboard.   * Assign students to groups representing different elements. * Each group identifies the atomic number and valence electrons for their element. * Give each element a different colour balloon reflecting the number of valence electrons. * One pupil becomes the element, with an atomic number and symbol and valence electrons stuck on them.   Students then move around the room locating their match (some examples include MgCl2, NaF, MgS, NaCl, CaO and Ne). Once a group has formed a compound they label their compound name and describe the movement of electrons. |  |
| 5.2.1.4 | When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong.  Covalently bonded substances may consist of small molecules.  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:  where n is a large number. | Recognise substances as small molecules, polymers or giant structures from diagrams showing their bonding.  Recognise common substances that consist of small molecules from their chemical formula.  Draw dot and cross diagrams for the molecules of hydrogen, chlorine, oxygen, nitrogen, hydrogen chloride, water, ammonia and methane.  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.  WS 1.2  Be able to visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.  MS 5b | 1 | Draw dot and cross diagrams for the molecules H2, Cl2, O2, N2, HCl, H2O, NH3 and CH4.  Draw these molecules using the other forms described in the Learning outcomes.  Ask students to predict the formula of covalent substances using a variety of different diagram formats. | Demo the formation of hydrogen chloride.  Ask students to draw the dot and cross diagram for this reaction and explain the results of the demonstration in terms of electrons and atoms.  Give students a diagram of the dot and cross diagram for a covalent substance and ask them to write out the formula.  Model simple covalent substance using molecular model kits.  Use strawberry shoelaces and gumdrops to model covalent bonding in H2, Cl2, O2, N2, HCl, H2O, NH3 and CH4. | Video clip:  [BBC Bitesize Covalent bonding and the periodic table](http://www.bbc.co.uk/education/clips/ztx4wmn) |
| 5.2.1.5 | 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: | Recognise substances as giant metallic structures from diagrams showing their bonding.  WS 1.2  Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.  MS 5b | 1 | Define ‘delocalised electrons’.  Draw a diagram to illustrate the different forms that bonding in metals can be represented by. Label the delocalised electrons. | Use copper wire and silver nitrate solution to grow silver crystals. Write an explanation to describe the reaction in terms of metallic bonding.  Students label themselves as a positive metal ion. Use balloons marked with a negative symbol to represent the electrons.  Each pupil is a metal atom; each balloon is an electron belonging to that atom. The balloons are gently tossed from hand to hand and every balloon must stay in the air.  The electrons are then transferred freely between atoms. | Video clips:  [BBC Bitesize The atomic structure of metals](http://www.bbc.co.uk/education/clips/zxy2hyc)  YouTube: [What are metallic bonds?](https://www.youtube.com/watch?v=S08qdOTd0w0) |

**5.2.2 How bonding and structure are related to the properties of substances**

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most students 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* |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 5.2.2.1 | 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. | Recognise that atoms themselves do not have the bulk properties of materials  WS 1.2  Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.  MS 5b. | 0.5 | Recap KS3 Chemistry by asking students to describe the properties of matter in a solid, liquid and gas using diagrams and words. | Use toothpicks and gum drops to model the three states of matter. | Video clips:  [BBC Bitesize Particle models of solids, liquids and gases](http://www.bbc.co.uk/education/clips/zhp87ty)  YouTube: [States of matter](https://www.youtube.com/watch?v=21CR01rlmv4) | |
| 5.2.2.1 | 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. | 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.  WS 1.2 | 1 | Define melting point and boiling point.    Plot a heating graph to compare the boiling points of methanol and ethanol.  Plot a cooling curve to compare stearic acid and salol. | Investigate the relationship between boiling points and intermolecular forces by heating methanol and ethanol in a water bath.  Investigate the relationship between melting points and intermolecular forces by cooling melted stearic acid and salol. | [BBC Bitesize Changes of state](http://www.bbc.co.uk/education/clips/zbrtfg8) | |
| 5.2.2.2 | 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 |  |  |  | |
| 5.2.2.3 | 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. | 1 | Write up the results from the circus of experiments.  Students should describe how the ions lead to the behaviours of each of the materials. | Use sodium chloride, copper (II) sulfate and potassium chloride.  Examine the crystalline of structure under a microscope.    Test the conductivity of the solid ionic compounds.  Use flame tests to determine the colours of the compounds.  Test the solubility by timing how long it takes each to dissolve.  Test the conductivity of the ionic compounds in solution. | Video clip  YouTube: [Ionic compounds and their properties](https://www.youtube.com/watch?v=TxHi5FtMYKk) | |
| 5.2.2.4 | 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 (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. | Use the idea that intermolecular forces are weak compared with covalent bonds to explain the bulk properties of molecular substances. | 1 | Describe the properties of small molecules.  Describe how soluble salt and salicylic acid are in the different liquids.  Compare the liquids to describe whether size or intermolecular forces are most important in terms of boiling point.  Compare the liquids to describe what forces are most important in terms of solubility. | Give students the size, structure, boiling and melting points of water, ethanol, acetone, and hexane.  Test solubility of NaCl in water, ethanol, acetone, and hexane.  Test solubility of salicylic acid in water, ethanol, acetone, and hexane. | Video clip  YouTube: [Properties of covalent compounds](https://www.youtube.com/watch?v=OQ-pcxo-Q5c) | |
| 5.2.2.5 | 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 | Recognise polymers from diagrams showing their bonding. | 1 | Draw a diagram of the structure of a polymer.  Describe the properties of polymers.  Link different polymers in their environment with their uses.  Students can practice drawing and interpreting polymer diagrams using a range of examples. | Model polymers using paper clips.  Make a slime polymer using borax solution (risk assessment) and PVA glue.  Make a biodegradable polymer using corn starch and vinegar.  Investigate the amount of polymer in chewing gum (if gum is chewed for 10 minutes, this removes all traces of sugar and flavouring, leaving behind the polymer). Mass can be measured before and after. | Video clips:  [BBC Bitesize The plastic revolution](http://www.bbc.co.uk/education/clips/zwt87ty)  [BBC Bitesize The uses of polymers](http://www.bbc.co.uk/education/clips/zht9jxs)  YouTube: [Polymerisation of propene & chloroethene](https://www.youtube.com/watch?v=nz1ucI6gCIg) | |
| 5.2.2.6 | 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. | Recognise giant covalent structures from diagrams showing their bonding and structure.  WS 1.2  MS 5b | 1 | Use the results of experiments to determine whether the sugar (covalent), table salt (ionic) and paraffin wax (covalent) are covalent or ionic compounds. | Compare the properties of table salt, sugar and paraffin wax.  Test the melting point of the three substances by heating on an aluminium foil boat.  Test the solubility by dissolving each material in distilled water.  Test the conductivity of the compounds from the solubility test. |  | |
| 5.2.2.7 | Metals have giant structures of atoms with strong metallic bonding. This means that most metals have high melting and boiling points.  In 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.  WS 1.2 | 1 | Describe the structure of metals.  Describe melting points and boiling points of metals and why they are high.  Describe the structure of metal alloys. | Model alloys using plasticine and various amounts of sand and test how ductile it is (pull a cylinder of sand-plasticine mix apart). | Video clips:  [BBC Bitesize The properties and uses of metals](http://www.bbc.co.uk/education/clips/zpg6n39)  [BBC Bitesize Bronze – the first alloy](http://www.bbc.co.uk/education/clips/zxgtfg8) | |
| 5.2.2.8 | 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. |  | 1 | Describe the structure of a metal atom.  Draw a diagram to show the delocalised electrons.  Draw a cartoon strip to describe why metallic substances are good conductors of electricity and thermal energy. |  |  | |

#### 5.2.3 Structure and bonding of carbon

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most students 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* |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 5.2.3.1 | 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.  WS 1.2  Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.  MS 5b | 0.5 | Draw the structure of diamond.  Describe the properties of diamond and relate it to the structure | Model the structure of diamond using gumdrops and toothpicks. | Video clips:  [BBC Bitesize Properties of diamonds](http://www.bbc.co.uk/education/clips/z8wvcdm)  YouTube: [Structure of diamond and graphite](https://www.youtube.com/watch?v=fuinLNKkknI) | |
| 5.2.3.2 | 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.  In graphite, one electron from each carbon atom is delocalised. | Explain the properties of graphite in terms of its structure and bonding.  Know that graphite is similar to metals in that it has delocalised electrons.  WS 1.2 | 0.5 | Draw the structure of graphite.  Describe the properties of graphite and relate it to the structure. | Model the structure of graphite using model kits.  Build a four-sided pyramid (diamond) and a cube (graphite) out of straws.  Students should devise a series of tests to work out which shape is strongest. | Video clip:  [BBC Bitesize Properties and structure of graphite](http://www.bbc.co.uk/education/clips/zwqb9j6) | |
| 5.2.3.3 | 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 (C60) which has a spherical shape.    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.  Give examples of the uses of fullerenes, including carbon nanotubes.  WS 1.2, 1.4  Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects.  MS 5b | 0.5 | Describe the structure properties and uses of graphene.  Describe the structure, properties and uses of fullerenes.  Describe the structure and uses of nanotubes.  Relate the structure to the properties for each of the three cases. | Test the electrical conductivity of graphite in a pencil lead (risk: use low voltage as wood is flammable).  Students can construct a paper model of a Buckyball (20 paper hexagons joined with 12 pentagon shaped empty spaces).  Use rolled chicken wire to demonstrate carbon nanotubes. | Video clips:  [BBC Bitesize Discovery and uses of graphene](http://www.bbc.co.uk/education/clips/znrhyrd)  YouTube: [Bucky Balls, Graphene and Nano Tubes](https://www.youtube.com/watch?v=nYEmiQCr3JU) | |