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| **Unit title: Elements.** |
| **Synopsis: *In this section put the why, what and how of the topic.*** | **What the research tells us: *In this section put an overview of what the research from Best Evidence tells us.*** |
| **Why are we teaching this content?** Student understanding of what it means to work scientifically is developed through the work of Dalton who used experimentation to develop the idea of proportionality. Dalton’s work is assessed against the steps of the scientific method attributed to Francis Bacon. This topic builds on the concept of particles studied recently and relates structure to physical properties by comparing properties of compounds and component elements. It begins to develop ideas about different types of substances (elements, compounds, molecules). Students start to develop an appreciation of the types of particles and how interactions between particles is related to both chemical and physical properties.The concept of chemical properties, and how they are distinct from physical properties, is addressed through familiar examples. These are fundamental ideas that help students understand and explain the scientific phenomena in the world around them that require understanding on a range of scales (e.g. the properties of substances and the carbon cycle). The Periodic Table is introduced as the home of the elements which reinforces the importance of elements in determining the properties and structure of all substances; the patterns within the table and importance of the table as a tool in science is developed later. **What are we teaching?****AQA:** Compare the properties of elements with the properties of a compound formed from them**Know:** Most substances are not pure elements, but compounds or mixtures containing atoms of different elements. They have different properties to the elements they contain (confined to physical properties). **Facts:** The symbols of hydrogen, oxygen, nitrogen, carbon, hydrogen, iron, zinc, copper, sulfur, aluminium, iodine, bromine, chlorine, sodium, potassium and magnesium.The Periodic Table only contains elements.**Skill:** Use particle diagrams to classify a substance as an element, mixture or compound and as molecules or atoms. Name simple compounds using rules: change non-metal to –ide; mono, di, tri prefixes; and symbols of hydroxide, nitrate, sulfate and carbonate.**Apply:** Name compounds using their chemical formulae. Given chemical formulae, name the elements present and their relative proportions. Represent atoms, molecules and elements, mixtures and compounds using particle diagrams. Use observations from chemical reactions to decide if an unknown substance is an element or a compound.**Extend:** Use particle diagrams to predict physical properties of elements and compounds. Deduce a pattern in the formula of similar compounds and use it to suggest formulae for unfamiliar ones. Compare and contrast the properties of elements and compounds and give a reason for their differences. Describe and explain the properties of ceramics and composites.**How are we teaching it (broadly)?**The work of Dalton and Democritus will be compared in relation to the scientific method. Dalton’s work is also used to develop the particle model and also to facilitate discussion over how situations in which either model might be used. This also introduces the concept of theories changing over time in response to new evidence.The Periodic Table is introduced as the home of the elements and students begin to familiarise themselves with it through identifying elements using their symbols. The patterns in the Periodic Table are explicitly addressed in a later topic (Periodic Table). Particles combining to form molecules and compounds are introduced for the first time through diagrams and modelling. The reactions are demonstrated in order to help students link the microscopic world of particles with scales that they are familiar with. The physical properties of substances are linked to their structures. Students compare the chemical and physical properties of compounds and their component elements. For example, through comparing the properties of water, whose properties make it essential for life, to those of hydrogen and oxygen which are reactive gases. | **Extracts from Best Evidence:** * Use emergent rather than additive methods when teaching atoms so students know that two atoms are do not
* E.g Students were shown a particle diagram for a blue substance and a yellow substance, each made of one type of atom. The students were then asked to predict the colour of a third substance made up of a combination of the two types of atom. Many responses took an additive approach and predicted that the colour of the compound would be green.
* Many students do not adequately understand particle diagrams including the significance of the circles touching (atoms joined) or not touching (atoms not joined).

*A key difficulty of students in integrating macroscopic with sub-microscopic understanding of an observed property is the use of an additive rather than an emergent framework. A research study (Talanquer, 2007) included a question to investigate this.* *Research (Rappoport and Ashkenazi, 2008) found that, in comparison with their students, university lecturers used an emergent way of thinking that considered the atoms or molecules interacting as part of an overall system. This was much less the case with students. Some students made connections in the reverse direction, that is to say they inferred properties on the atoms or molecules that related to the macroscopic property. The research concludes that the explicit inclusion of an emergent way of thinking in teaching programmes would be beneficial to students and would help to dispel some misunderstandings.* *The progression pathway has been constructed to check understanding of the link between properties and the structural arrangement, and type of atom that a substance (element or compound) is made up of. It also uses findings from the Children’s Learning in Science Project (Briggs and Holding, 1986) which showed that many students do not adequately understand particle diagrams including the significance of the circles touching (atoms joined) or not touching (atoms not joined).* A review of empirical research (Taskin and Bernholt, 2012) revealed three problem areas for students: *Language*This includes problems with the meaning, function and syntax of chemical formulae.*Conceptual understanding*This problem area arises from either “a misunderstanding or a missing understanding” of the particulate nature of matter or from difficulties in making transitions between symbolic expressions and sub-microscopic representations or macroscopic observations. *Inadequate selection and interpretation of formulae*Difficulties in this area become more significant in more advanced study of chemistry. It includes difficulties in deciding when to attach which meaning to a particular chemical representation or when to choose a specific chemical representation for a given purpose.A research study (Al-Kunifed, Good and Wandersee, 1993) also showed that many students regard element symbols and chemical formulae only as simple abbreviations. This misunderstanding risks being reinforced by introductory teaching of the topic. A wide range of research has found that students have difficulty moving between representational ‘levels’ (symbolic, sub-microscopic and macroscopic) summarised in Johnstone’s triangle (Johnstone, 1991).The first two student outcomes therefore begin with interpretation of element symbols and chemical formulae to check that students recognise that they can represent more about substance than just the name.The next two outcomes specifically address difficulties students experience in linking symbolic representations to sub-microscopic representations. Diagnostic questions check whether students can match chemical formulae (or expressions including a multiplying coefficient) with particle diagrams. This type of activity risks giving rise to the misunderstanding that all chemical formulae represent discrete molecules. The final outcome therefore relates to the interpretation of chemical formulae as a ratio.**Johnstone’s triangle**Microchemistry techniques helping in learning chemisry - Microchemuk |
| **Threshold concepts: What concepts do student need to have prior knowledge of?**  | **Which topics develop the concepts from this one?**  |
| **LEAVE FOR NOW****Particles.** | **LEAVE FOR NOW****Bonding**  |

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| **Links to KS3 programme of study:** |
| **Atoms, elements and compounds*** **a simple (Dalton) atomic model**
* **differences between atoms, elements and compounds**
* **chemical symbols and formulae for elements and compounds**
* **conservation of mass changes of state and chemical reactions**

**Pure and impure substances*** **the concept of a pure substance**
* **the identification of pure substances**

**The periodic table****the varying physical and chemical properties of different elements** |
| **Links to KS2 programme of study:** | **Links to KS4 programme of study:** |
| **Y3 – Properties of rocks****Y4 – States if matter*** **observe that some materials change state when they are heated or cooled, and measure or research the temperature at which this happens in degrees Celsius (°C)**
* **identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature**

**Y5 – Properties and changes of materials** **compare and group together everyday materials on the basis of their properties, including their hardness, solubility, transparency, conductivity (electrical and thermal), and response to magnets** | **Atomic structure and the Periodic Table*** **a simple model of the atom consisting of the nucleus and electrons, relative atomic mass, electronic charge and isotopes**
* **the number of particles in a given mass of a substance**
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| **Cross-curricular links:** | **Wider development:**  |
| **Maths: This can be left for now****English:** | **SMSC:****PLTS:** **SEAL:****Numeracy and literacy: Literacy includes keystone words** |

**Lesson sequence: Copied from the route through. You might need to make the notes more coherent. Also, check the best evidence files do fit with the lesson.**

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| **Lesson title** | **Best evidence (diagnoastics)** | **Notes** |
| Elements | Properties of copper (response: property mistakes); element differences; describe what an element symbol represents | Focus on the arrangement and interaction of atoms explaining properties; the properties of the particles are not the same as macroscopic particles.Introduction to symbols for elements and what they represent. Explaining properties (e.g. melting point and boiling point) in terms of structure (simple molecules vs giant structure). Include classification of different representations as solids, liquids or gases |
| Dalton and proportionality | None | The question of to what extent Dalton worked scientifically should be addressed |
| Elements and compounds | Counting substances | Include classification of different representations as solids, liquids or gases |
| Formulae | Chemical formula; formula choice (response: formula practice); more than one molecule (response: molecule expressions) |  |
| Deeper meaning of formulae | Interpreting chemical formulae | This is a separate lesson to build appreciation of formulae as ratios (e.g. in ionic substances). Knowledge of other types of formulae is not required (they will be addressed later). Refer back to state and properties. |
| Properties of compounds vs properties of component elements | Which colour? |  Some ideas can be found on the RSC page ‘How to teach elements and compounds’. Students need to understand that the properties of compounds are different to the properties of their component elements. **We will not be doing the experiment to make Iron Sulphide. The associated risks outweigh the benefits when alternatives exist.**  |
| Pure substances and mixtures | Element, mixture or compound? (response: drawing diagrams) | Mixtures have been left to the end because students need to have an appreciation of elements and compounds before they can fully understand mixtures. This lesson feeds into future work on separating mixtures. Students need to understand that in a mixture the components retain their physical properties whereas elements combined into a compound do not.  |

**Lesson sequence and lesson overviews**

**Essential questions: INTERACTIVE – LOOK AT OTHER SUBSTANCES AND PROPERIES – WHAT PARTICLES LOOK LIKE – FORMULAE**

* What do scientists think about and why is it important?
* When is simplifying situations in science optional and when is it mandatory? When is it a good idea and when is it a bad idea?
* How are models similar or different from the natural world?
* How should this be modelled? What are the strengths and weaknesses of this model?
* What are all things made of and how do these things interact?
* How does the nature of the unseeable explain what we can see?
* To what extent does structure explain function and properties?

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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 1 | **Elements.****Keywords:** **Element****Atom** **Molecule****Chemical symbol** | **Know the strengths and weaknesses of the particle model of matter and how the model can be used to represent elements. –BALLS/shapes****Know the definitions of atoms, elements and molecules and explain how they are related. –OWN WORDS****Know the structural similarities and differences between elements that have monoatomic, molecular and giant structures. –USE IMAGES****Understand how the movement and arrangement of particles in an element, and the forces between them, determine the macroscopic properties of an element. –particle images to properties (Simple/giant)****Understand the deeper meaning of chemical symbols. In particular, the microscopic and macroscopic properties of the elements. –LINK TO arrangement of particles H20 are all separate and NaCl is a ratio – all joined**  | * Definition of an element as a substance that cannot be broken down into other substances.
* Definition of an atom as the smallest particle of an element that can exist.
* Definition of a molecule as two or more atoms strongly joined together (strong forces between them).
* Representing elements as ‘molecular’, monoatomic and ‘giant’ structures.
* Reminder of the Periodic Table as the home of the elements.
* Chemical symbols as the representation of an atom and the elements macroscopic properties.
* Explaining the macroscopic properties of elements in terms of arrangement and movement of particles and the strength of forces between them.
* Predicting macroscopic properties from arrangement, movement and forces between particles.
 | * Electronic structure of atoms.
* Complex definition of an atom as simplest non-charged particle.
* Structure of compounds.
* Patterns of reactivity in the Periodic Table. the best approach.
 | **CONNECT**Students predict particle arrangement, strength of forces between particles and melting point for iron and gold.Scanning-tunnelling electron micrographs on following slide showing regular arrangement. This is a reminder of the particles topic but also a first step towards addressing Johnstone’s Triangle.**MODELLING**Students find definitions for keywords using KS3 or KS4 texts (as directed by teacher). Apply to diagrams of particle arrangements. Embedded video explaining difference between monoatomic, molecular and giant structures. Opportunity to role model or build models to show the difference between different structures applied to elements. **ME TIME**From arrangement of particles in diagrams, students decide which state each element would be. Questioning needs to identify depth of understanding in preparation for the next phase of the lesson. **Opportunity to use fading.** **MODELLING**Introduction to Johnstone’s Triangle to help students connect microscopic properties, macroscopic properties and symbolic representations. Students predict properties from arrangement of particles or arrangement from given properties. **Opportunity to model thought processes and / or use fading.** **ME TIME**Questions that relate structure to properties in silver and hydrogen. The previous section serves as modelling.  |
| Notes including most common misconceptions |
| What the research says: A research project investigated student perceptions of atoms, including any misunderstandings about the atom being a ‘piece of the matter’ that has the macroscopic properties of the substance. This question was inspired by the title of the research article “Is an atom of copper malleable?” (Ben-Zvi, 1986).*More recent research suggests that the fundamental sources of many students’ difficulties in chemistry is a failure to understand the emergent nature properties of chemical substances and their interactions. It is therefore recommended that the concept that properties emerge from the collective arrangement of atoms that make up a substance should be taken into account when addressing students’ misunderstandings (Tümay, 2016).*This learning outcome is inspired by the fourth unit developed for a study (Johnson, 2000) into the development of students’ understanding of the concept of substance. In this study elements and compounds were explained in terms of atoms and molecules with both ‘molecular’ and ‘giant’ structures being given as possibilities. This is earlier than these ideas are typically introduced in chemistry courses however the idea is useful in explaining, in general terms, the low and high melting points of different substances.*At this stage, whilst considering changes of state, the emphasis should be on the substance remaining the same. Later, when studying chemical change, students should be more able to recognise that changes in the combination of atoms must result in different properties, and hence new substances. (Johnson, 2002)***A review of research on students’ understanding of chemical formula (Taskin and Bernholt, 2012) reports research that observed that only a minority of students could identify the different meanings of element symbols. Many students thought simply that the symbol was an abbreviation of the name of the element. A research study (Al-Kunifed, Good and Wandersee, 1993) found that students were influenced by pre-existing experiences of symbols in everyday life and mathematics**.*Solely regarding an element symbol as a shorthand way of writing an element name means that students, when seeing an element symbol, may not be prompted to recall or picture macroscopic information about the element. Additionally, lack of recognition that an element symbol can represent an atom (or atoms) of an element may make the understanding of chemical formulae more difficult.*Applications* Identifying and justifying macroscopic properties of elements when given information about particle arrangement, movement and inter-particle forces.
* Identifying possible position of element in Periodic Table based on particle arrangement, movement and strength of forces.
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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 2 | Dalton and proportionality**Keywords:** **Atom** | **Know the conclusions that Dalton drew from his work.** **Understand how the evidence that Dalton collected led to the conclusions that he drew.** **Know the scientific method and able to explain the extent to which Dalton used it in his work.** | * Dalton’s work on atom and proportionality.
* Dalton’s concept of a compound.
* The extent to which Dalton worked scientifically.

 | * The full history of atomic structure.
* Models of the atom that followed Dalton’s model.
* Sub-atomic and charged particles.
* The details of chemical reactions.
 | **CONNECT**John Dalton quote. Students explain why scientists and student’s ned to be assiduous. This connects to literacy and also successful studying through useful skillsets. This theme builds up through the topics.**MODELLING**Dalton’s postulates are given as images. This enables the teacher to describe his ideas (including what we now know is wrong. See postulate 3). **NB: Dalton’s postulates are sometimes expressed as 5 postulates and sometimes more. This does not change his message.** There are two videos:1. Compares the ideas of Dalton and Democritus2. Focuses on Dalton’s ideasThere is the opportunity to model the rearrangement of atoms here. This would enable multisensory learning and give a deeper understanding. **ME TIME**Literacy task: Students use reading skills to answer questions about Dalton himself and his ideas. Whilst knowledge of scientists, their values and their lives are not part of the National Curriculum they are essential to enabling students to relate to the person and the subject. **Slides describing reading skills should enable modelling of those skills.**This theme is developed throughout the course. **MODELLING**Students are reminded of the scientific method. **ME TIME**Students determine if Dalton acted scientifically by referring to the stages in the method and the previous literacy task. |
| Notes including most common misconceptions |
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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 3 | Elements and compounds**Keywords:** **Element****Compound** **Molecule** | **Know the definition of a compound and understand how they relate to elements.** **Understand how the particle model has been modified to accommodate formation of compounds during chemical reactions.** **Know how to represent molecular compounds and compounds with a giant structure using the particle model.** **Understand how to use the arrangement and movement of particles and the forces between them to explain the physical properties of compounds.**  | * Definition of compounds as a substance made of atoms of two or more elements strongly joined / bonded together.
* Representing compounds as ‘molecular’ or ‘giant’ structures.
* Explaining the macroscopic properties of compounds using knowledge of their particle arrangements, movement and inter-particle forces.
* Compound are made when elements or other compounds undergo chemical reactions.
* Molecular compounds have low melting and boiling points because changes of state involve overcoming weak intermolecular forces.
* Giant structures have high melting and boiling points because changes of state involve breaking strong forces between atoms.
 | * Ionic and covalent bonding.
* Differences between ionic and covalent substances.
 | **CONNECT**Questions related to the properties of oxygen based on the arrangement of particles at room temperature and pressure. Also, interpretation of the image in terms of number of elements present. This connects to previous learning in this topic and in a previous topic. It also serves as a reminder of Johnstone’s Triangle. Alternative Connect task uses the macroscopic properties to decipher structure. **MODELLING**Students use a KS3 or KS4 textbook to define ‘compound’ and then demonstrate understanding through identifying a compound in an image. **ME TIME**Students identify compounds in a series of diagrams. They should explain their choices. **MODELLING**The structure of giant molecular compounds and simple molecular compounds are described. **ME TIME**Students explain why different types of compound have different properties. **A WAGOLL to help students understand what a high quality answer looks like.**  |
| Notes including most common misconceptions |
| What the research says: Research carried out through the Children’s Learning in Science Project (Briggs and Holding, 1986) showed that a large proportion of students failed to appreciate that two circles in contact represented atoms that were joined (combined). Instead, they regarded the atoms as being intermingled in some way. This led to confusion for students in distinguishing a diagram showing a single compound made up of molecules containing two different types of atom with another diagram showing a mixture of atoms of two elements.  |

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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 4 | **Formulae****Keywords:** **Chemical formula****Ratio** | Know how to interpret the formulae of molecular compounds and elements.Understand the meaning of coefficients and subscript values in formulae.Understand the relationship between microscopic properties, macroscopic properties and formulae (Johnstone’s Triangle).  | * How to interpret the formula of a substance in terms of numbers of each atom. To include elements and molecular compounds.
* Writing the formulae of different molecular substances from images.
* Interpretation of formulae including coefficients and subscripts.
* Understanding substances in terms of Johnstone’s Triangle (submicro, macro and formulaic).
 | * Balancing equations will not be covered at this point.
 | **CONNECT**Students need to understand simple ratios for this lesson. This is part of the KS2 Programme of Study for Maths. There are several activities so you can find out their level of understanding of ratios. There are also additional resources in the folder to support explicit teaching of ratios where required. **MODELLING**Reminder of Johnstone’s Triangle with an indication that todays lesson addresses the symbolic portion. **Modelling of how to determine the formula of a molecule. This could utilise fading alongside making your thinking explicit.** **ME TIME**Several options for students to practice working out the meaning of a formula for a simple compound. **MODELLING**Relating coefficients to the number of molecules. **This lends itself well to fading and explicit thinking.****ME TIME**Identifying numbers of molecules in different examples.**MODELLING**This section pulls together information from this lesson and prior learning on identifying properties / types of molecules when given information. Several examples are given with answers. **Model using fading and explicit thinking.** **ME TIME**Students apply content form this lesson and prior learning to the equation for respiration.  |
| Notes including most common misconceptions |
| What the research says: A research study (Al-Kunifed, Good and Wandersee, 1993) found that many students misunderstandings about chemical formulae related to previous every day and mathematical experience.A chemical symbol was interpreted by some students in the same terms as a symbol met in day-to-day life. These students perceived a chemical formula as simply an abbreviation used because it would take chemists ‘too long to write out the words’. A proportion of students thought that a chemical formula was a chemical equation. This may be due to a prior concept of a (mathematical) formula.Other students thought that only compounds have a formula (and hence that O2 was not a formula).Whilst this study was relatively small in scale, a review of the empirical research (Taskin and Bernholt, 2012) details many similar misunderstandings found in more recent research.A review of empirical research (Taskin and Bernholt, 2012) describes different ways in which students were found to interpret chemical formulae. Some students assumed that a chemical formula provided a code for the order of connections within a substance. This meant that some students also thought that HS and SH were different substances. Other students linked the subscript numbers to the subsequent element rather than the preceding one.A review of empirical research (Taskin and Bernholt, 2012) describes student misunderstandings in translating chemical formulae into particle diagrams. The inclusion of a multiplying coefficient (for example 2N2O) caused additional difficulties. Some students confused the meaning of a subscript with a multiplying coefficient. They drew O2 as two separate atoms and 2N as two atoms joined. Another study observed that some students who were given the expression 2NO2 matched it with a diagram showing two separate N atoms and an O2 molecule. In other words, they did not recognise that NO2 was an integrative formula for a substance that could not be broken down into discrete particles. Instead they appeared to have regarded 2N as separate to O2.The review also summarises research findings that concluded that these misunderstandings were contributory factors to student difficulties in balancing chemical equations.Applications  |

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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 5 | Deeper meaning of formulae**Keywords:** **Chemical formula, Ratio** | * Know how to represent giant structures using a formula.
* Understand why formulae for giant structures are represented as ratios
* Understand the meaning of coefficients and subscript values in formulae.
* Understand the relationship between microscopic properties, macroscopic properties and formulae (Johnstone’s Triangle).
* Able to identify compounds as molecular or giant structures using information supplied (formulae and information related to physical properties at room temperature).
 | * Writing formulae for elements and compounds that form giant structures.
* Explaining why the formula is a simplified ratio rather than a fixed ratio (linking formulae to microscopic)
* Interpreting coefficients and subscripts in relation to formulae.
* Explaining the properties of giant structures in terms of particle arrangements, movement and forces between atoms (linking microscopic to macroscopic properties).
 |  | **CONNECT**Connection to prior learning. Interpreting properties in terms of likely structure and the strength of forces between atoms. Alternatively, how John Dalton might explain the properties of diamond. **MODELLING**Discussion on how giant structures might be represented as a formula given they are massive and do not have fixed numbers of atoms. Simplifying formulae to the simplest ratio is then modelled. **ME TIME**Students practice simplifying formulae. **MODELLING**Explicit teaching of Johnstone’s Triangle and how to use it. **ME TIME**Application to questions about Carbon Dioxide and Potassium Chloride. |
| Notes including most common misconceptions |
| What the research says: As part of a review of the empirical research (Taskin and Bernholt, 2012) on student understanding of chemical formulae, the authors cite their own project in which students were asked to match diagrams with different chemical formulae. The majority of students were found to be able to choose the correct diagram when the chemical formula represented as substance made up of individual molecules. However, when presented with the chemical formula of a substance with a giant structure (such as an ionic compound) most students still selected a diagram representing a molecular compound.Applications |

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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 6 | Properties of compounds vs properties of component elements**Keywords:** **Chemical reaction****Property****Observation****Accurate** | * Know that the properties of compounds differ to those of their component elements.
* Able to give examples of compounds (including biological molecules)
* Able to give examples that demonstrate that compounds have different properties to their component elements.
* Able to make accurate observations related to properties of substances.
* Able to explain the differences in properties in terms of particle arrangement, movement and forces between particles.
 | * The properties of compounds are different to the properties of their component elements; the properties of component elements are not additive.
* The importance of high quality observations to the scientific method.
 | * The reaction of iron with sulphur will not be used as risks outweigh the benefits and alternatives exist.

Relevant demonstrations can be found here: <https://edu.rsc.org/cpd/elements-and-compounds/3009350.article>  | **CONNECT**Several optical illusions are given. Students need to say what they see. Students need to recognise that the accuracy of observations is important so they need to observe carefully. This will be revisited throughout the course. **MODELLING**Explaining how scientists make observations. **ME TIME**Questions related to what observations might be made when observing a chemical reaction. **MODELLING**Students identify properties of reactants. They then observe the reactions and determine properties of the products. Some videos are supplied but it would be better to demonstrate reactions or allow students to perform some (Hazcarda and Risk Assessments **must** be read). **ME TIME**Students identify that the properties of reactants are different to those of products.They also look at why there might be differences in observations made. There is also a stretch literacy task: Case study of the Wakefield / MMR controversy and why scientific observations are always repeated.  |
| Notes including most common misconceptions |
| **Demonstrations should be used to show the differences in properties of compounds and their component parts.** **Focus will be on accurate observations using a range of senses (where safe to do so)**What the research says: A study (Talanquer, 2008) was designed to explore the extent to which ‘novice’ learners (university students) used an additive framework to predict the properties of a compound rather than recognising the emergent nature of these properties which result from the interactions of atoms that make up the system as a whole. Multiple choice questions were devised in which students were presented with basic properties (such as smell or colour) of individual substances before being asked to predict the properties of a substance made up of a combination of atoms from the original substances.The majority of student answers were consistent with the use of an additive framework. Less than 3% of students systematically predicted that the compound would have distinct properties to substances made up of its constituent atoms |

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| Lesson | Title and keywords | Objectives | What students are learning | What students are not learning | Suggested activities |
| 7 | Pure substances and mixtures**Keywords:** **Pure****Property****Mixture** | * Know the scientific definition of ‘pure substance’ and ‘mixture’.
* Able to recognise pure substances and mixtures in images showing distributions of particles.
* Able to recognise pure substances and mixtures from heating and cooling curves.
* Able to recognise elements, mixtures and compounds in diagrams.

 | * Pure substances contain only one substance.
* The scientific definition of a pure substance is different to the everyday definition.
* Mixtures contain two or more substances that can be elements or compounds. The particles of the different substances are not joined together (forces between them are weak).
* Pure substances have a fixed melting point and boiling point. Mixtures do not.
* You can change the amounts of different substances in a mixture. You cannot change the proportions of the different components of a compound without making a new substance.
* Distinguishing elements, mixtures and compounds in diagrams.
* The physical properties of the components of a mixture are the same as the physical properties of the isolated components.
* The physical properties of the components of a mixture can be used to separate them.
* The properties of compounds are different to their component parts whereas the properties of the components of mixtures are unchanged.
 | The range of separation techniques are covered in a later topic. The focus should be on demonstrating that physical properties of the components do not change when they are part of a mixture. | **CONNECT**Connect to prior learning. Identifying elements and compounds from diagrams.Identifying ‘pure’ substances; this tells you their starting point. **MODELLING**Video on pure and impure substances.**ME TIME**Case study of Nestle Pure Life. **MODELLING**Two practical’s are suggested. The first demonstrates that the boiling point of water does not change when it is part of a mixture. The second enables students to construct a cooling curve. **ME TIME**Several options are given. a. Students classify statements according to whether they relate to compounds or mixtures. b. Questions relating to the distillation of a mixture.  |
| Notes including most common misconceptions |
| Misconceptions include:Research carried out through the Children’s Learning in Science Project (Briggs and Holding, 1986) showed that a large proportion of students failed to appreciate that two circles in contact represented atoms that were linked-up (combined). Instead, they regarded the atoms as being intermingled in some way. This led to confusion for students in distinguishing a diagram showing a single compound made up of molecules containing two different types of atom with another diagram showing a mixture of atoms of two elements. Whereas some students focused on the diagram showing two different types of atoms in order to identify a compound, a small proportion considered that a diagram of a diatomic element represented a compound. These students had recalled the need for atoms to be joined in order to form a compound but not that these atoms must be different.A very small proportion of students confused a representation of a single compound with an element explaining that the ‘molecules were the same’.Applications |