Topic 3 Classifying matter: Elements, compounds and mixtures

Prior knowledge

Properties of solids, liquids and gases

1 **a** solids

b solids, liquids

c gases

d solids, liquids

2 Sample answer:

I do not agree with this statement because adding helium to the balloon makes the balloon get heavier, because all gases have mass. However, the helium in the balloon is less dense than the air around the balloon (accept helium is a lighter gas than air). This is what causes the balloon to rise upwards.

Particle theory

3 The particles in a liquid are moving relatively slowly, they are closely packed together and the attractions between the particles are fairly strong.

4 The pressure in the cylinder forces the particles close together so that substance becomes a liquid. When the pressure is released, the particles can spread out and it returns to the gas/gaseous state.

5 The particles move more quickly and (start to) separate from each other as the attractions between the particles weaken.

Types of mixtures and separating mixtures

6 **a** Salt, a solute, is soluble in water, which is the solvent. When the salt dissolves in the water, a solution (salt water) is formed.

b The salt can be recovered by allowing the water to evaporate (which can be done by heating the salt water).

7 **a** Nitrogen is the most abundant gas in air.

b Sample answers:

The amounts of each gas can change because air is a mixture of gases. In a mixture the components are not chemically combined, and the composition is not fixed.

or:

Many processes, such as burning, photosynthesis and respiration use up or produce the gases that make up the air. Therefore, the amounts of each gas present are constantly changing.

3.1 Elements, atoms and symbols

Check your understanding

SC1: I can explain what an atom is

a Atoms are the smallest individual piece of matter that can exist by itself/You can't break an atom down into smaller parts/particles.

b Atoms are extremely small/cannot be seen, even using a microscope. All things are made up from atoms.

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SC2: I can recall that elements are made up of only one type of atom

Elements consist of only one type of atom, and since only 118 different atoms exist, there are only 118 elements. However, these elements can combine in many different ways to form a vast range of substances.

SC3: I can state a range of elements and represent them with their symbols

a He
b Hg
c Au
d Mg
e Mn
f Fe
g Na
h Cl

Lesson review

1 **a** C
b An allotrope is when the same substance can exist in two or more different forms. For example, carbon can exist in the form of diamond (an extremely hard crystalline substance used in jewellery) or graphite (a relatively soft black solid used for pencil leads). The differences are due to the way that the atoms are arranged in the different allotropes.
c hydrogen and oxygen

2 **a** Mn is used for a different element, manganese (which was discovered in 1774).
b Dmitri Mendeleev
c Mendeleev proposed the idea of the (modern) periodic table to organise elements based on their properties.

3 **a** flames = Fl (flerovium), Am (americium), Es (einsteinium)
b aspirin = As (arsenic), P (phosphorus), Ir (iridium), I (iodine), N (nitrogen)
Or
aspirin = As (arsenic), P (phosphorus), Ir (Iridium), In (indium)
c dynamite = Dy (dysprosium), N (nitrogen), Am (americium), I (iodine), Te (tellurium)

4 An atom is a single particle that cannot be broken down into smaller particles (that can exist on their own). An element is a substance that is made up of a single type of atom.

5 **a** americium, francium
b mendelevium, curium
c copper, sodium

6 **a** carbon atoms
b bonds/links between the atoms
c Answers may include: There are more strong bonds in diamond compared to graphite/the atoms are closer together in diamond/some bonds in graphite are weaker than the bonds in diamond/some arrangements are stronger than others.

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3.2 Observing and describing elements

Results

Sample table:

	Symbol	State (solid/ liquid/ gas)	Colour	Solubility in water (does it dissolve?)	Density (sink or float)	Reaction with hydrochloric acid	Hydrogen gas produced
copper	Cu	solid	red/ brown/ brass	no	sink	no	no
iron	Fe	solid	grey	no	sink	yes	yes
aluminium	Al	solid	silver	no	sink	yes	yes
zinc	Zn	solid	grey	no	sink	yes	yes
tin	Sn	solid	grey	no	sink	slow	yes, but probably not enough to be collected
magnesium	Mg	solid	grey	no	sink	yes	yes

Conclusion

1 All the samples were solid. They were also all metals.

2 Sandpaper was used to remove any oxide coating/corrosion. An oxide coating or corrosion can affect how an element reacts.

3 Bubbles indicated that there was a gas. If the gas gave a characteristic 'pop' sound when lit, it can be concluded that the gas was hydrogen.

Evaluation

1 Answers may include:

- not collecting the right equipment
- not producing a sufficient results table
- seeing bubbles when the sample reacted with acid but not collecting the gas
- not recording the density correctly
- not removing the oxide coating to allow the acid to react.

2 Answers will vary.

3 Answers will vary.

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3.3 Elements and compounds

Check your understanding

SC1: I can describe differences between elements and compounds

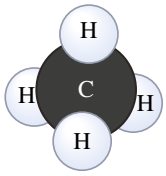
Both compounds are made up of molecules. However oxygen molecules (O_2) contain only one type of atom so this is an element. Carbon dioxide molecules (CO_2) contain two types of atoms (carbon and oxygen) so this is a compound.

SC2: I can list many different types of elements and compounds found in everyday items

a Argon is an inert/unreactive element/gas.

b Any two from neon, helium, xenon, krypton, radon, because they are also inert gases. Can also accept nitrogen as this is an unreactive gas. Note that radon is a dangerous gas because it is radioactive, so would not be used for food packaging, even though it is a chemically inert gas.

SC3: I can draw diagrams that demonstrate the differences in particle arrangement between elements and compounds



Lesson review

1 **a** Compounds are pure substances because they contain only one substance.

b Compounds contain atoms joined together with other types of atoms.

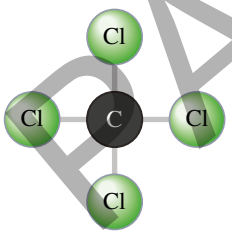
c Some elements are made up of individual atoms, but some are made up of atoms that are joined to form molecules (or networks).

2 **a** Molecules made up of two oxygen atoms joined/bonded together.

b Molecules made up of two hydrogen atoms joined to one oxygen atom.

c Any three from: carbon dioxide, carbon monoxide, sulfuric acid, acetic/ethanoic acid, chlorophyll or any other compound of oxygen.

3



4 **a** Elements, such as oxygen, nitrogen and argon only contain one type of atom. Compounds contain more than one type of atom. For example, carbon dioxide (CO_2) is made up of carbon atoms and oxygen atoms.

b Atoms are the simplest 'building blocks' of all materials. Molecules are particles that contain more than one atom joined together. For example, nitrogen exists as N_2 molecules that contain two nitrogen atoms. Argon exists as individual atoms.

c In compounds, elements are combined together in fixed proportions. Air is a mixture of a number of gases including oxygen, nitrogen, carbon dioxide and argon and these substances are not chemically combined with each other (so can be easily separated). The amount of each substance in samples of air can also vary.

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3.4 The use of gases from the air

Check your understanding

SC1: I can describe how the understanding of gases in the air changed as a result of scientific investigation

Oxygen is used up when substances burn in air so can be removed by burning/combusting materials in the sample of air. Argon is an unreactive gas, so cannot be removed using a chemical reaction.

SC2: I can describe how carbon dioxide is used to carbonate water and how this has influenced society

a Fermentation, combustion, reaction of acid with chalk/carbonate

b The carbon dioxide is pumped into the water at high pressure.

c When carbon dioxide dissolves in water, it forms a new compound called carbonic acid. This increases the acidity of the water (which changes the taste of the water) and the water becomes fizzy.

SC3: I can describe how oxygen can be separated from air and how oxygen can be used in a range of situations

a Chemical energy from nutrients is converted into energy used by cells and oxygen is converted to carbon dioxide.

b Environmental management using bacteria, life support for astronauts or scuba divers, medical applications such as treatment of asthma and pneumonia, emergency situations such respiratory failure.

c Answers may include:

Oxygen is required for the process of cellular respiration.

In low oxygen environments, such as space or underwater, oxygen is supplied to allow people to breathe and survive.

or:

For individuals with conditions that limit oxygen intake, transport or processing—such as asthma or pneumonia—supplemental oxygen is provided to ensure they absorb enough oxygen to survive.

or:

Aerobic bacteria can be used to break down waste materials so they can be recycled back into the environment. These bacterial require oxygen to grow and survive.

Lesson review

1 The new gas was oxygen. Oxygen is essential for cellular respiration which provides energy for living things so the mice were able to live longer.

2 The carbonation of water allowed a new range of fizzy/sparkling drinks which increased the market for these drinks. Carbonated water was also the basis for the soft drinks industry, with numerous fizzy drinks that contain sugar and other flavourings.

3 The carbon dioxide is added to the water at high pressure which means more of the gas can dissolve into the water.

4 **a** People with asthma are sometimes not able to absorb enough oxygen through their lungs. By increasing the concentration of oxygen in the air that they breathe, more oxygen can be absorbed into the blood (so it can be used to release energy for the body).

b In a fire there may be limited amount of oxygen (due to the fire using the oxygen in the air) so oxygen might be provided for the firefighters in their breathing apparatus.

5 In the process of distillation, air is cooled to produce liquid air. As the liquid air warms up, the gases in the air will evaporate (turn back into their gaseous form). The substances with lower boiling points will evaporate back into gases first. Nitrogen will turn to a gas first once the temperature reaches –196°C so it can be separated from the liquid oxygen which won't evaporate until the temperature reaches –183°C.

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6 **a** The amounts of nitrogen and oxygen have increased significantly, whereas the proportion of gases such as carbon dioxide and methane are much lower now than they were in the early atmosphere.

b Plants have converted carbon dioxide into oxygen (through photosynthesis).

c Carbon dioxide is required for photosynthesis in plants. Can also accept that carbon dioxide has a significant impact on Earth's climate/global temperatures.

3.5 Properties of elements and compounds

Results

Sample results:

Compounds

Substance	Formula	Elements present	State	Colour	Texture	Solubility (does it dissolve in water)
sugar (sucrose)	$C_{12}H_{22}O_{11}$	carbon, hydrogen, oxygen	solid	white	grainy/ small crystals	yes
table salt (sodium chloride)	NaCl	sodium, chlorine	solid	white	grainy/ small crystals	yes
rust (iron oxide)	Fe_2O_3	iron, oxygen	solid	red-brown	crumbly/flaky	no

Elements

Substance	Symbol	State	Colour	Texture	Solubility (how well it dissolves in water)
carbon (graphite)	C	solid	black/grey	smooth/hard	insoluble
hydrogen	H	gas	clear		insoluble
oxygen	O	gas	clear		slightly soluble
sodium	Na	solid	silver/white	soft	reacts violently with water (to produce hydrogen gas)
chlorine	Cl	gas	yellow-green		slightly soluble
iron	Fe	solid	shiny grey	smooth/hard	insoluble

Conclusion

1 A compound is made of two or more elements chemically combined. For example, sugar contains the elements carbon, oxygen and hydrogen.

2 Answers may include:

Table salt is a white solid that dissolves in water and is safe to eat. It is made from toxic yellow-green chlorine gas and a very reactive metal, sodium.

Sugar is a white solid that contains two elements (oxygen and hydrogen) that are gases and carbon that can be a black solid (graphite).

Rust is a brown solid and its elements are a gas (oxygen) and a shiny grey metal (iron).

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3 Answers may include the idea that when the atoms/elements join, new particles are formed and these different particles will cause the substances to have different properties.

4 Answers may include water, which is a liquid that contains two elements (oxygen and hydrogen) that are both gases; or nitrogen, which is a colourless gas that does not dissolve in water but fertilisers/proteins/amino acids that contain nitrogen are (often white) solids that can dissolve in water.

Evaluation

1 Answers may include not being able to test/observe all elements, or that it was difficult to tell if the solids dissolved.

2 Answers may include using a larger range of elements and compound, measuring out exact quantities for the solubility tests, warming the water to make it easier/quicker to test the solubility, or just testing elements that are solid so that it is easier to compare their properties.

3.6 Mixtures and compounds

Check your understanding

SC1: I can describe mixtures as substances that can be separated into pure substances

By adding water to dissolve the salt, filtering the mixture so that the sand stays in the filter paper, and then evaporating the water to retrieve the salt.

SC2: I can list a range of different types of mixtures and pure substances found in everyday items

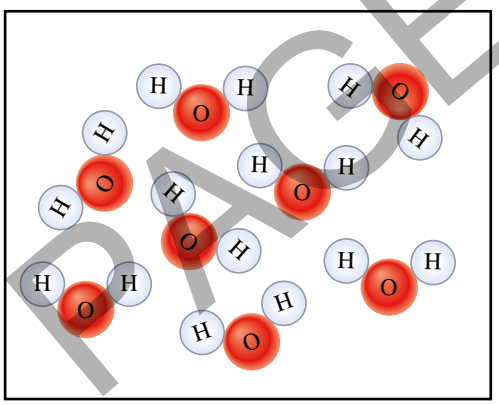
Answers may include:

Mixtures: Salad, salt water, flour mixed with sugar.

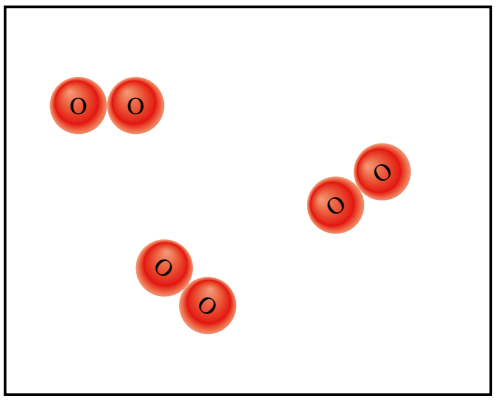
Pure substances: Table salt (NaCl), sugar (sucrose), distilled water (H_2O).

SC3: I can draw diagrams that demonstrate the differences in particle arrangement between mixtures and pure substances

a pure water (H_2O)



b pure oxygen (O_2) gas



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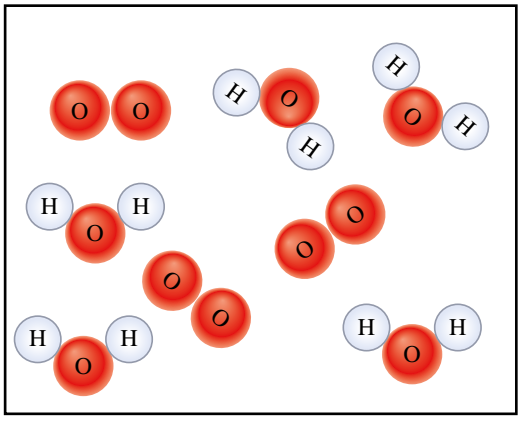
c oxygen dissolved in water



Lesson review

1 The mixture can be separated by using a magnet to attract and remove the iron filings, leaving the sulfur powder behind because iron is magnetic and sulfur is not, so sulfur will not be attracted to the magnet.

2 **a** mixture

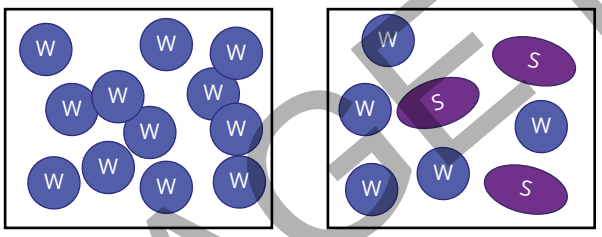
b pure substance

c mixture

d pure substance

3 Apple juice is a mixture because it contains various substances like water, sugars and vitamins that are not chemically combined. Copper wire is a pure substance because it is made up of only copper atoms (Cu) throughout.

4 Pure water contains only H_2O molecules, whereas salt water contains H_2O molecules along with sugar particles/molecules dispersed throughout.



pure water sugar solution

3.7 Metals and non-metals

Results

Sample results table:

	Appearance	Malleable (yes/no?)	Ductile (yes/no?)	Reactive (yes/no?)	Conducts electricity (yes/no?)
Iron nail	grey solid with slight lustre, some discolouration	yes	yes	yes	yes
Stainless steel nail*	very shiny silver-like solid	yes	yes	no	yes
Copper strip	brown/orange solid with slight lustre, some discolouration which is removed with sandpaper	yes	yes	yes	yes

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Magnesium strip	grey solid with slight lustre, some white solid on surface which is removed with sandpaper	yes	yes	yes	yes
Chalk	white solid with smooth, powdery surface	no	no	no	no
Plastic	smooth solid	no (depends on plastic used)	no (depends on plastic used)	no	no
Brass tack*	dark brown solid with slight lustre	yes	yes	no	yes
Wood	brown solid with rough surface	no	no	no	no
Graphite	black solid with smooth surface	no	no	no	yes

Conclusion

1 Metal: magnesium strip, brass tack, iron nail, stainless steel nail, copper strip.
Non-metal: chalk, plastic, wood, graphite (non-metal – potentially hard to classify).

2 Metals are towards the left of the periodic table.

3 Copper and zinc. Alloys are made of metals so they will have similar properties to metals.

4 The chromium reduces the reactivity of the steel which makes the material less likely to corrode.

5 Corrosion will happen on boats due to the presence of water so a material that is resistant to corrosion is required.

6 Plastic does not conduct electricity so wires are coated with it so they can be touched safely.

Evaluation

1 Graphite might have been hard to classify as it had some properties of a metal (conducted electricity), but other properties of a non-metal.

2 Answers may include problems with clear observations, difficultly in predicting malleability and ductility, and problems with the electric circuit.

3.8 Producing a metallic element

Prediction

Zinc is more reactive than copper so will replace it in solution, and the copper will form crystals.

Results

1 Brown deposits start to form.

2 The blue of the solution starts to fade.

3 The particles are pink/brown and have a crystal-like structure.

Conclusion

1 copper: 1; sulfur: 1; oxygen: 4

2 Copper is an orange/brown solid that does not dissolve in water. Copper sulfate is a blue substance that dissolves in water.

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3 Copper sulfate in solution is blue. As the copper started to come out of the solution and form solid deposits there was less copper sulfate present so the colour faded.

4 According to the reactivity series of metals, zinc is more reactive than copper. This means zinc will displace the copper from solution. Two pieces of evidence that support this are copper deposits forming on the zinc, and the solution starting to fade as the copper comes out of solution.

5 Copper is quite unreactive so will not corrode easily or react with chemicals in the food and it conducts heat well.

Evaluation

Answers may include:

- Using a camera to capture the changes in the solution and on the zinc metal.
- Increasing the surface area of the zinc or the concentration of the copper sulfate to try to produce more copper.
- Experimenting with using different metals to try to displace the copper.
- Using a different solution to try to produce a different metallic element.

3.9 Particles in substances

Check your understanding

SC1: I can recall the particle arrangement in elements, molecules, compounds, mixtures and pure substances

A pure substance is made of only one type of substance, either an element or a compound. In a pure substance all the particles are identical.

SC2: I can compare the key features of structures including molecules, metals and non-metallic lattices

a Metals have closely packed atoms held together by metallic bonds that allow atoms to slide over each other, making metals malleable and ductile.

Non-metallic lattices have a highly ordered arrangement of atoms that are very hard and strong but brittle because the atoms cannot normally move past each other.

b Graphite is made of layers of carbon atoms. The bonds between these layers are weak, allowing them to slide over each other easily. In the structure of diamond, all the bonds between the atoms are strong.

Lesson review

1 Oxygen (O_2) is a diatomic molecule with two oxygen atoms bonded together. Diamond is a non-metallic lattice made of carbon atoms in a highly ordered, repeating structure.

2 In a particle diagram, a compound would show different types of atoms chemically bonded together in a fixed ratio, while a mixture would show different types of particles physically combined but not bonded, and they could be separated by physical means.

3 When a metal is bent or its shape is changed, the bonds between atoms still hold them together in a strong, flexible structure. This allows the metal to stay in one piece without breaking easily.

4 In diamond each carbon atom is bonded to four other carbon atoms in a very strong network. Graphite, on the other hand, has layers of carbon atoms bonded in sheets with weak bonds between the layers, making it softer.

5 **a** Copper is a pure substance and an element. Its particle arrangement consists of closely packed copper atoms held together by metallic bonds.

b In bronze, the copper atoms would be mixed with atoms of tin. These different types of atoms are not chemically bonded together but physically mixed (resulting in a mixture where the properties of the alloy differ from pure copper).

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3.10 Chemical formulas

Check your understanding

SC1: I can recall the formulas of some familiar chemical compounds

a NaOH

b CO_2

c NaCl

SC2: I can identify atoms from chemical formulas of compounds

$C_6H_{12}O_6$ = Carbon: 6, Hydrogen: 12, Oxygen: 6.

SC3: I can write the names of some unfamiliar molecular substances from their chemical formulas

a sulfur trioxide

b silicon dioxide

c phosphorous pentachloride

d carbon tetrafluoride

Worked example: Try yourself

WHAT DO MOLECULAR FORMULAS REPRESENT?

Thinking	Working
Identify the elements in the compound by looking at the symbols.	There are two symbols Cu (copper) and Cl (chlorine).
Use the subscripts to identify the number of each atom.	Copper (Cu) does not have a subscript so there is one copper atom. Chlorine (Cl) has a subscript of 2 so there are two chlorine atoms for every one copper atom.
Summary	Copper: 1 Chlorine: 2

Lesson review

1 **a** NH_3

b one nitrogen atom and three hydrogen atoms

c two nitrogen atoms, four hydrogen atoms and three oxygen atoms

2 sodium dichromate ($Na_2Cr_2O_7$): sodium (2) chromium (2) oxygen (7)
ethanol (C_2H_5OH): carbon (2) hydrogen (6) oxygen (1)

3 NO = nitrogen monoxide
NO_2 = nitrogen dioxide
N_2O = dinitrogen monoxide
NO_5 = nitrogen pentoxide

4 **a** Formula: P_2O_5 Name: diphosphorous pentoxide

b Formula: PCl_5 Name: phosphorous pentachloride

3.11 Modelling the arrangement of atoms in compounds

Design

Answers should include specific materials, including quantities based on being able to create models of all five compounds. This will include materials required to make 14 hydrogen atoms, 1 sulfur atom, 7 carbon atoms, 13 oxygen atoms, around 6 sodium and chlorine atoms and numerous links to join the atoms together (around 40–50).

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Improve

1 Answers may include additional use of colours/keys/labels/scales and so on.

2 Answers may include additional use of colours/labels/different materials/models that have different sizes for different atoms/greater number of atoms (especially for the NaCl).

Evaluate

1 A formula tells you the types of atoms in the molecule and the number of each type of atom using subscripts. Models can show how the atoms are joined together. Two-dimensional models can show bonds between atoms and help to indicate the size of the molecules, whereas three-dimensional models can show the shape of the molecules and the distances between atoms in the molecule.

2 Formulas: to communicate the elements that make up the compound. This can be easily seen from the symbols and the subscripts in the formula.

Two-dimensional models: to communicate the structure of the compound with information about how the atoms are bonded together. Two-dimensional representations can be easily created and shared.

Three-dimensional models: to communicate the structure and shape of the compound. Three-dimensional representations reveal more detail and are more engaging than two-dimensional models, and can be used to compare the structures of different compounds.

3.12 Structure and properties of substances

Prediction

Sample prediction: If a substance has a similar structure to another substance, it will have similar properties.

Results

Structure	Substance	State	Appearance	Hardness	Solubility in water (soluble or insoluble)	Melting point (high or low)
Molecular	water	liquid	colourless	N/A	N/A	low
	nitrogen	gas	colourless	N/A	N/A	very low
Metal	copper	solid	shiny bronze colour metal	malleable	insoluble	high
	iron	solid	shiny silvery/ grey metal	hard	insoluble	very high
Non-metallic lattices	salt	solid	small white crystals	hard/sharp edges	soluble	very high
	sand	solid	small beige/ brown crystals	granular/hard	insoluble	very high

Conclusion

1 Molecular: low melting points

Metals: shiny/strong/high melting point

Non-metallic lattice: hard/high melting point

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2 Sample answer:

The observations support the hypothesis because substances with similar structures had similar properties as predicted. For example both metals had a high melting point. However, there were some differences, such as salt was soluble and sand was insoluble, even though they both contain non-metallic lattices.

3 Substances with lattice structures are hard and have high melting points because their atoms are held together by strong chemical bonds throughout the lattice. These bonds require a large amount of energy to break, keeping the substance solid with a fixed shape and making it resistant to melting or deformation.

4 Diamond: Non-metallic lattice as it is very hard and has a high melting point.

Candle wax: Molecular as it has a low melting point.

Limestone: Non-metallic lattice as it is hard, has a high melting point, but is not shiny, distinguishing it from metallic lattices.

Topic review

Remember

1 **a** Mg

b Mn

c Md

d Hg

2 **a** gold

b beryllium

c barium

d arsenic

3 Methane and glucose are compounds.

4 Answers may include any four properties of metals: shiny appearance, conduct electricity, strong, high melting point, conduct heat, malleable, ductile

5 Hydrogen gas can be produced by adding (dilute) hydrochloric acid to magnesium (accept zinc) metal.

Understand

6 Neon, sodium chloride and gold do not contain molecules.

7 **a** These symbols come from the Latin names of the elements. (Copper from *cuprum* and iron from *ferrum*).

b Co is the symbol for cobalt and Ir is the symbol for iridium.

8 **a** An atom such as Ne, N or H, is the smallest particle of a substance that can exist on its own and a molecule is two or more atoms joined/bonded together, such as N_2 or NH_3.

b An element contains only one type of atom, such as neon and nitrogen. A compound contains more than one type of atom, for example ammonia which contains nitrogen and hydrogen.

c Nitrogen is made of molecules that contain two atoms.

9 **a** salt (common name), sodium chloride (scientific name), NaCl (formula)

b white solid/crystals

c Answers may include: The properties of a compound can be very different to the properties of the elements that make up the compound./The properties change when atoms are combined in different arrangements.

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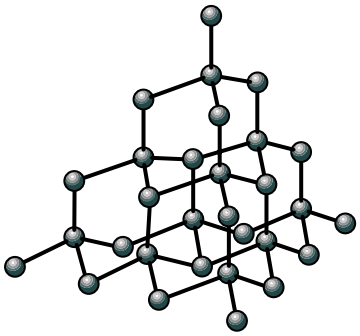
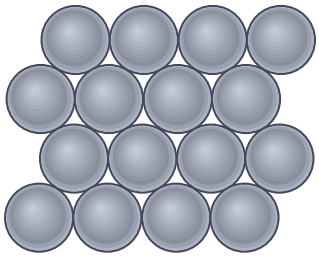
10 a Strong means that a material can withstand a large force without breaking. Hard means that a material can withstand a large force without changing shape.

b Diamond is made of a network of carbon atoms all held together by strong bonds between the atoms.



c Tungsten is a metal and metals are held together in a giant three dimensional lattice/network held together by bonds that act in all directions.



When a force is applied to the metal, the atoms can 'slide over' each other into new positions without breaking these bonds, so the metal does not break.

Apply

11 Potassium has the following properties: soft/shiny-grey colour/reactive (reacts with water)/flammable (burns easily).

12 a The mixture contains two elements and two compounds.

b This represents a heterogeneous mixture.

c Heterogeneous means non-uniform composition. In this mixture, the substances are not evenly spread around in the mixture, so this is a heterogeneous arrangement.

13 a Substance A is a metal.

b Substance A does not shatter when hit with a hammer as it has the ability to change shape (and absorb the impact without breaking the metallic bonds).

Analyse

14 a Answers may include: The candle wax contains a certain amount of phlogiston and when this is used up the candle will not burn any more./The phlogiston released from the burning candle 'contaminates' the air and stops the candle being able to burn.

b Answers may include: There is only a certain amount of oxygen (around 20%) of oxygen in the air. Substances need oxygen to burn, so when all the oxygen is used up by the candle, it can no longer burn as the air has no oxygen left.

c Answers may include: Carbon dioxide does not support burning/combustion. Therefore, the carbon dioxide given off from the burning candle extinguished the flame/prevents oxygen getting to the flame.

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15 a Elements A, C, F are likely to be metals.

b A substance that changes shape when hit is known as malleable.

c Connect the metals in an electric circuit and identify whether they conduct electricity or not.

d Element C could be copper.

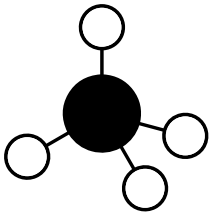
e Element E could be graphite, a form/allotrope of the element carbon.

16 a The chemical formula for glucose is $C_6H_{12}O_6$.

b Answers may include any three from:

- how many bonds each atom forms
- the arrangement of the atoms/bonds
- the (relative) size of the atoms
- the fact that some carbons form a ring shape
- how close the atoms are to each other/space taken up by atoms
- the overall shape of the molecule

c



Extension: Research task

17 a Ag (silver), Pb (lead), Li (lithium), Co (cobalt), Ni (nickel), Cu (copper)

b Answers may include:

Silver: Used as the element for components such as switches and connections (because it is very resistant to corrosion). It is also used in small 'button' batteries such as those used in hearing aids.

Lithium: Used in lithium-ion batteries used in many rechargeable devices such as smartphones, laptops and tablets, cordless power tools, drones, e-scooters, robotic vacuum cleaners and electric vehicles (EVs). It is present in the battery as lithium the element and the compound lithium oxide.

Lead: Lead-acid batteries are used in petrol and diesel vehicles, including cars, trucks, motorcycles, and boats. They are also commonly used as a backup for renewable energy systems. The lead is used in the form of the element (for the electrodes) but is converted to the compound lead oxide when the batteries are used, as well as lead sulfate when the lead reacts with sulfuric acid in the battery.

Cobalt: Cobalt is used as an electrode in lithium-ion batteries and is therefore used in electric vehicles (EVs) and many rechargeable devices such as smartphones and cordless power tools.

Nickel: Nickel is used in electrodes in a range of batteries. Nickel can increase the capacity of batteries, and therefore make them last longer before having to be recharged – very important in vehicles.

Copper: The element copper is used in batteries for electrodes and connectors (because it is an extremely good conductor of electricity).

c Answers may include:

Silver: Silver containing compounds include argentite (silver sulfide, Ag_2S) and cerargyrite (silver chloride, AgCl) and is also present as an impurity in the lead ore galena (PbS). Silver is extracted from underground mines, with crushed ore being transported to the surface. Silver minerals are extracted in Broken Hill in South Australia Broken Hill and Mt Isa in Queensland.

Lithium: Lithium can be extracted from the compound spodumene ($LiAl(SiO_2)_3$, note that there are other ways to present this formula and other compounds such as lithium carbonate (Li_2CO_3).

Lithium can be extracted from underground mines in the form of solid ores or dissolved in water (called brines). Most lithium deposits are found in Western Australia, including the Greenbushes Mine, the largest lithium mine in the world.

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Lead: The main compound of lead that is mined is galena (lead sulfide, PbS). Lead is mined from underground mines which are highly automated at Broken Hill in South Australia, Mount Isa and Hilton in Queensland and McArthur River in the Northern Territory.

Cobalt: Occurs naturally as smalite (cobalt arsenide, $CoAs_2$) and cobaltite (cobalt sulfarsenide, CoAsS). Cobalt is mined in a range of locations in South Australia including the Claude Hills, Mount Gunson and the Flinders Ranges.

Nickel: Nickel compounds that are mined include Nis[$(Ni,Fe)_9S_8$], and nickeliferous limonite [(Fe,Ni)O(OH)]. Nickel is extracted from underground mines or open pit mines on the surface. All nickel in Australia is produced in Western Australia, including mines at Leinster and Ravensthorpe.

Copper: Ores of copper include malachite (Copper carbonate hydroxide, $CuCO_3.Cu(OH)_2$) and cuprite (copper oxide, Cu_2O). Most of the copper in Australia is extracted from underground mines but in other parts of the world it is sourced from open cut mines on the surface. Copper is extracted at Mount Isa in Queensland and Olympic Dam in South Australia.

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