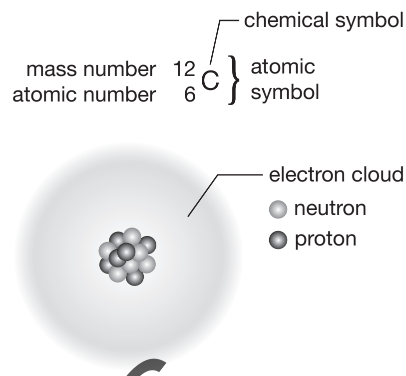
1.1 Atomic symbols

Knowledge and understanding

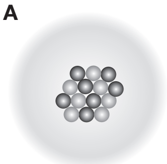
N Numeracy CCT Critical and creative thinking

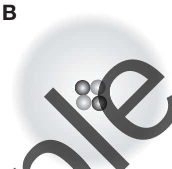
Scientists use atomic symbols to communicate information about an atom. The atomic symbol is made up of the chemical symbol for the atom, the atomic number and the mass number. The atomic symbol of the carbon atom is shown here.

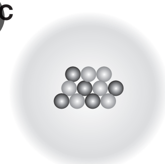


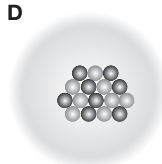
carbon atom

1 The atomic number is equal to the number of protons. The mass number is equal to the number of protons plus the number of neutrons. **Calculate** the number of protons and neutrons in the atoms below.

A

Protons = ______
Neutrons = ______

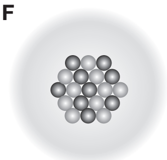
B

Protons = ______
Neutrons = ______

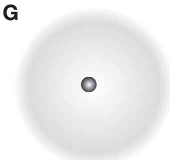
C

Protons = ______
Neutrons = ______

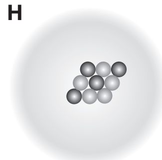
D

Protons = ______
Neutrons = ______

E

Protons = ______
Neutrons = ______

F

Protons = ______
Neutrons = ______

G

Protons = ______
Neutrons = ______

H

Protons = ______
Neutrons = ______

2 **Match** the letter for each atom in question 1 to its correct atomic symbol below.

${}^{16}_{8}\mathrm{O}$	${}^{1}_{1}\mathrm{H}$	${}^{14}_{7}\mathrm{N}$	${}^{7}_{3}\mathrm{Li}$
______	______	______	______
${}^{4}_{2}\mathrm{He}$	${}^{9}_{4}\mathrm{Be}$	${}^{11}_{5}\mathrm{B}$	${}^{19}_{9}\mathrm{F}$
______	______	______	______

1.2 Isotopes

Working scientifically

N Numeracy **CCT Critical and creative thinking**

The number of protons in an atom's nucleus tells us the type of atom it is. For example, all oxygen atoms have 8 protons, all chlorine atoms have 17 protons and all gold atoms have 79 protons. The number of protons in the nucleus is known as the *atomic number*.

The *mass number* is the number of protons plus neutrons in the nucleus. Atoms with the same atomic number but different mass numbers are known as *isotopes*. For example, carbon atoms have 6 protons but may have 6, 7 or 8 neutrons. This gives three isotopes: carbon-12, carbon-13 and carbon-14. The number 12, 13 or 14 refers to the mass number.

Tim has a 65 g block of zinc metal. He knows that zinc has an atomic number of 30 and five stable isotopes: zinc-64, zinc-66, zinc-67, zinc-68 and zinc-70. He measures the amount of each isotope in his 65 g block. He then creates the table shown in question 2.

1 **Calculate** the number of neutrons in each isotope.

Zinc-64: ____________

Zinc-66: ____________

Zinc-67: ____________

Zinc-68: ____________

Zinc-70: ____________

2 **Calculate** the fraction of each zinc isotope in the 65 g block of zinc. Round your answer to two decimal places (0.00).

The fraction is found by: $\frac{\text{mass of isotope}}{\text{total mass}}$

For example, there is 31.4 g of zinc-64 in Tim's sample. Therefore the fraction of zinc-64 $= \frac{31.4\text{ g}}{65.0\text{ g}} = 0.48$.

Complete the second row of the table below.

Isotope	Zinc-64	Zinc-66	Zinc-67	Zinc-68	Zinc-70	Total
Mass of isotope (g)	31.4	18.2	2.67	12.3	0.43	65.0
Fraction of isotope	0.48					1.00
Angle on pie chart	172.8°					360°

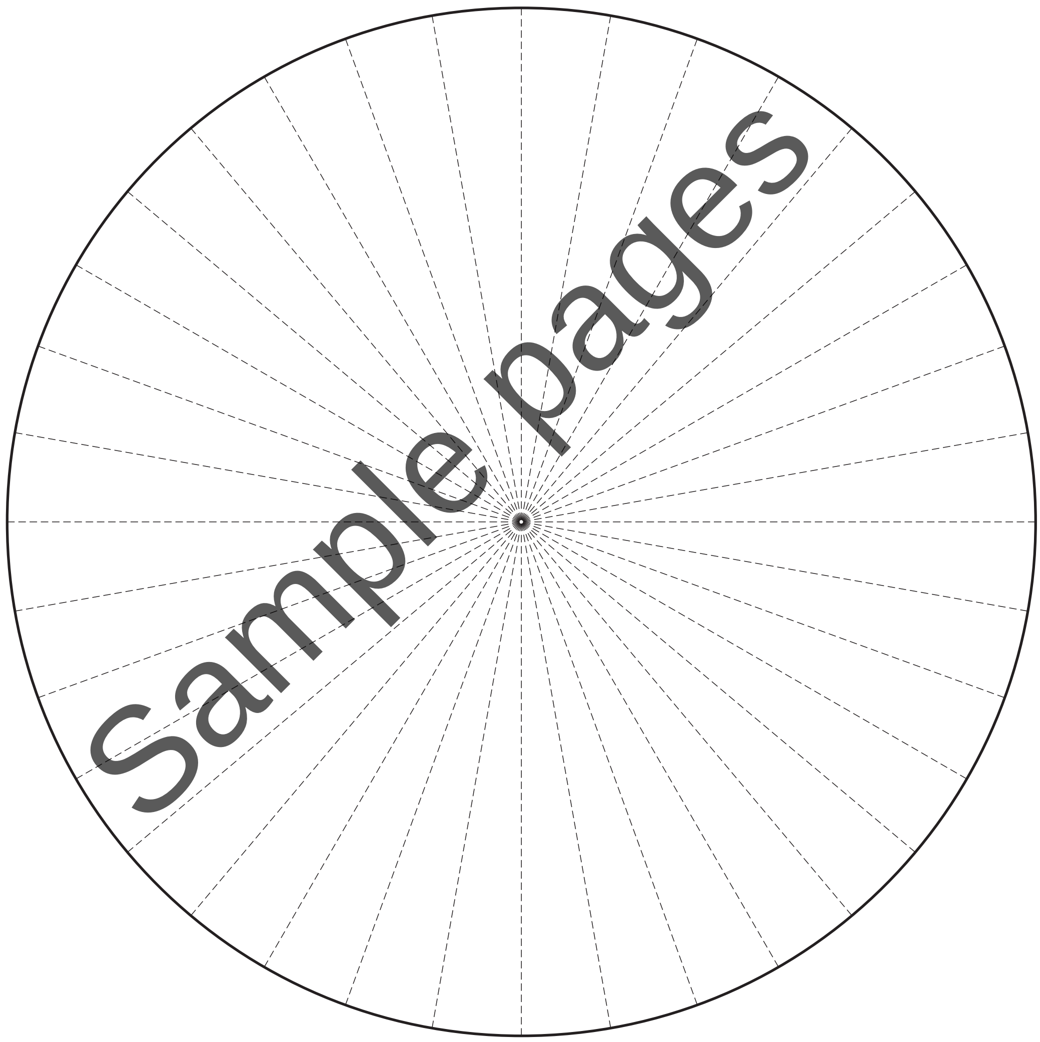
3 **Construct** a pie chart in the circle below to show the proportions of the zinc isotopes in Tim's sample. To do this:

a Fill in the third row of Tim's table. Calculate the angle of each piece of the pie. To do this, multiply the fraction of each isotope in row 2 by 360°. For example, 0.48 × 360° = 172.8°

b Use a ruler and a protractor to draw the pieces of pie on the pie chart. **Hint:** Each segment of this pie chart corresponds to 10°.

c Choose a colour for each isotope and colour the key.

d Colour each piece of the pie according to your colour key.



Key: ☐ Zinc-64 ☐ Zinc-66 ☐ Zinc-67 ☐ Zinc-68 ☐ Zinc-70

1.3 Model scientists

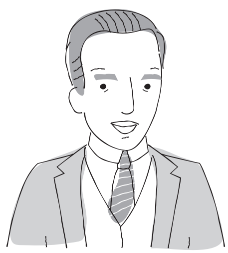
Knowledge and understanding

L Literacy **CCT Critical and creative thinking**

As scientists' understanding of atoms has grown, they have developed new models to represent atoms. Refer to the Learning Across the Curriculum in unit 1.1 in your student book to read more about the development of atomic models.

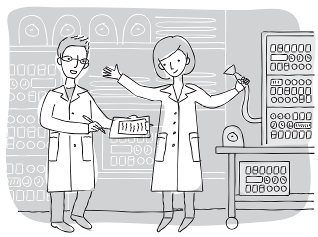
1 **Identify** the scientist with the atomic model that made him famous.

A Ernest Rutherford



B Niels Bohr

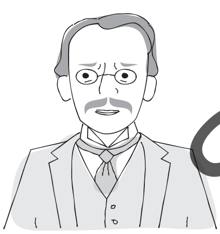
C Sir James Chadwick



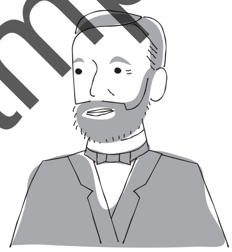
D Modern atomic physicists

E Democritus

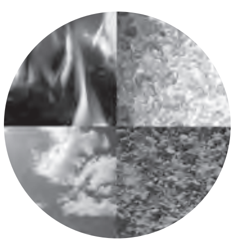
F Ancient Greek philosophers



G Sir Joseph J. Thomson

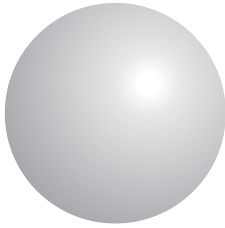


H Philipp Lenard



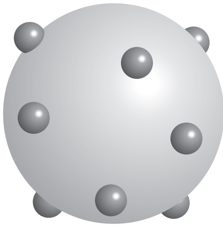
Continuum model
Substances are made up of the four elements: air, fire, water and earth. Substances can always be broken down into smaller pieces of the same substance.

Scientist: ____________________



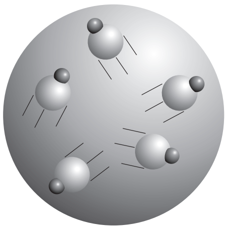
Hard sphere model
Substances are made up of hard, ball-like building blocks called atoms that cannot be broken apart.

Scientist: ____________________



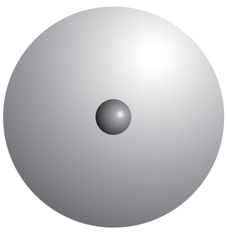
Plum pudding model
Atoms are made up of a positively charged ball with negatively charged electrons stuck in it.

Scientist: ____________________



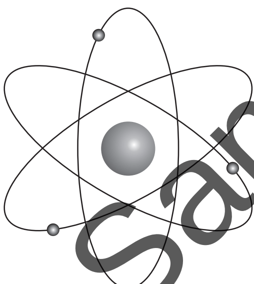
Dynamide model
Atoms are made up of moving particles called dynamides. Each dynamide is made up of a positively charged particle and a negatively charged particle.

Scientist: ____________________



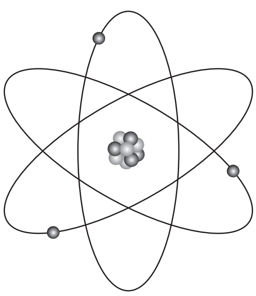
Nuclear model
Atoms are made up of a solid, positively charged nucleus surrounded by an electron cloud.

Scientist: ____________________



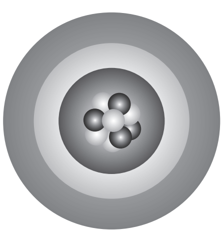
Planetary model
Atoms are made up of a solid, positively charged nucleus surrounded by electrons orbiting the nucleus like planets orbiting the Sun.

Scientist: ____________________



Neutron planetary model
Atoms are made up of a positive nucleus that has both protons and neutrons. The nucleus is surrounded by electrons orbiting it like planets orbiting the Sun.

Scientist: ____________________



Electron shell model
Atoms are made up of a positive nucleus that has both protons and neutrons. The electrons form shells around the nucleus.

Scientist: ____________________

1.4 Comparing alloys

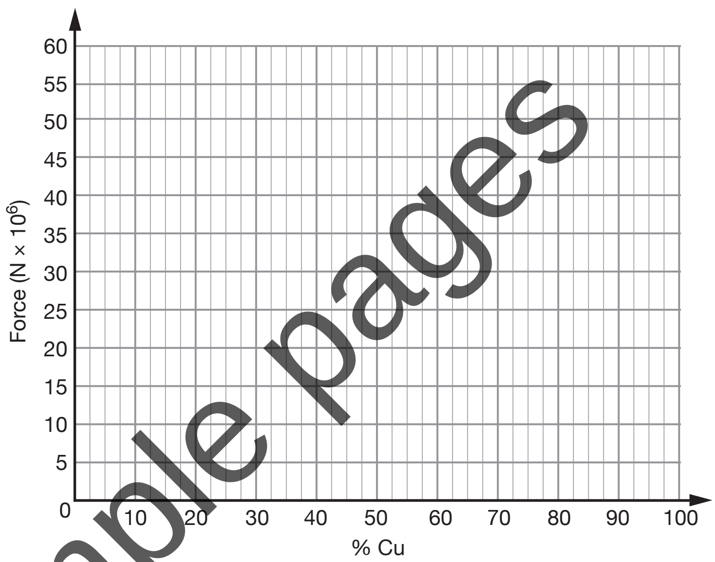
Working scientifically

N Numeracy **CCT Critical and creative thinking**

Copper (Cu) and zinc (Zn) can be mixed together to form alloys of different strengths. For example, different strengths of brass can be obtained by mixing different proportions of copper and zinc. The table below shows the force that different alloys of copper and zinc can take before breaking.

% Cu	0	10	20	30	40	50	60	70	80	90	100
Force (N × 10^6)	19	16	12	8	5	32	58	40	23	21	33

1 On the grid (right), **construct** a line graph of force plotted against the percentage of copper (horizontal axis). Do not draw a line or curve of best fit but connect the points together with a curve drawn smoothly through them.



2 **Use** your graph or table to **predict** the breaking strength of:

(a) a 50/50 alloy of copper/zinc ______

(b) an alloy of 25% Cu and 75% Zn ______

(c) an alloy containing 25% zinc ______

(d) pure copper ______

(e) pure zinc. ______

3 **Predict** the proportions of copper and zinc that are needed to make the alloy stronger than pure copper.

______

4 **Predict** the proportions of zinc that make the alloy weaker than pure zinc.

______

5 **State** the percentage of copper that makes the strongest alloy. ______

6 **State** the composition of three alloys that all break when a force of 25×10^6 N is applied to them.

______ ______ ______

Changing the strength

EXTENSION

Knowledge and understanding

L **Literacy** CCT **Critical and creative thinking** WE **Work and enterprise**

Materials such as glass and steel develop different properties when heated or when treated with chemicals. *Annealing* (or normalising) is a process in which glass and steel are heated and then left to cool naturally. While glass is toughened by the process, steel is softened, making it easier to shape into wires and cables.

Tempering is a process in which glass and steel are repeatedly heated and then quenched (cooled rapidly) to make them tougher. Tempered glass is also known as safety glass because it forms small (and safe) rounded beads when broken. For centuries, blacksmiths have used tempering to toughen and shape steel tools, horseshoes and the blades of knives and swords.

Heat can also cause disaster. When it is hot, steel acts like plastic, and stretches and bends if force is applied to it. Steel structures tend to droop and collapse in an extreme fire. This often happens in factory fires. It is likely that steel structures drooped and collapsed on 11 September 2001, after the Twin Towers of the World Trade Center in New York, United States, were struck by aircraft piloted by terrorists. Both towers withstood the initial collisions, but exploding aircraft fuel ignited fires in the buildings. This intense heat caused the steel structures holding up the upper floors to sag and pull in the outer walls of both towers. The weakened walls could not hold the weight of the floors above them and so they collapsed. The impact of the collapsing upper floors then caused the lower walls to collapse again and again until the whole tower had collapsed.

1 **State** alternative names for:

(a) annealing ______________________

(b) tempered glass. ______________________

2 (a) **Define** *quenching*.

____

____

(b) Blacksmiths need to quickly quench red-hot horseshoes. **Propose** how they do this.

____

____

3 **Compare** the process of annealing with tempering.

____

____

____

4 Compare annealed glass with normal glass.

5 Propose a use for:

(a) tempered glass

(b) tempered steel.

6 Compare the behaviour of steel at room temperature with steel at extremely high temperature.

7 Aircraft colliding with the World Trade Center towers in New York caused a chain of events that ended in the towers collapsing. **Outline** how the collision changed the materials in the towers enough to cause them to collapse.

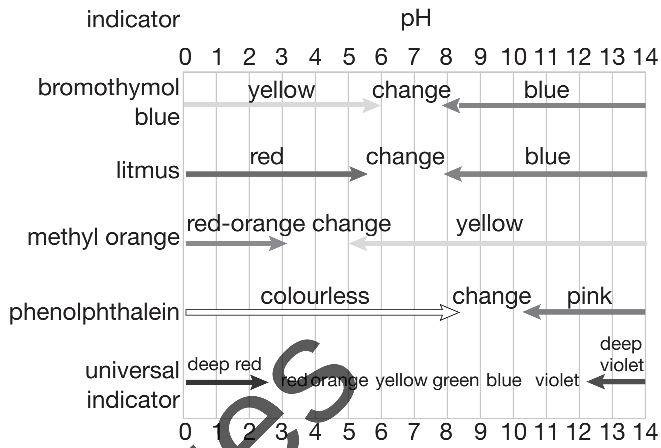
Working scientifically

N **Numeracy** **CCT** **Critical and creative thinking**

Different indicators turn different colours at different pH values.

Predict what colour each material would give if tested with the indicators shown.

Use your answers to complete the table below.



	pH	litmus	bromothymol blue	methyl orange	phenol-phthalein	universal indicator
floor cleaner	10.0					
ammonia solution	11.0					
brass polish	9.5					
calcium hydroxide solution	11.9					
carpet shampoo	5.9					
cream cleanser	8.8					
dilute caustic soda	13.0					
dilute nitric acid	1.0					
dishwashing liquid	5.5					
kitchen cleaner	11.0					
lemon juice	2.5					
milk	6.8					
oranges	3.2					
oven spray	12.5					
tea	5.2					
toothpaste	6.8					
vinegar	2.9					
wine	3.8					

1.7 Shape memory alloys and surgery

EXTENSION

Knowledge and understanding

L Literacy CCT Critical and creative thinking PSC Personal and social capability

In surgery, shape memory alloys (SMAs) are used because nickel and titanium are compatible with human tissues and rejection is unlikely. Nitinol is used inside arteries to filter out blood clots after surgery. These filters trap the clots and allow them to be dissolved in the blood. The device is manufactured so that it is open when warm. It is placed inside the artery using a tube filled with cool salt solution. When it is in position, the cooling is stopped and the device is left in the artery. The device warms up with body temperature, expands and stays in place inside the artery. A Nitinol filter is shown in Figure 1.7.1.

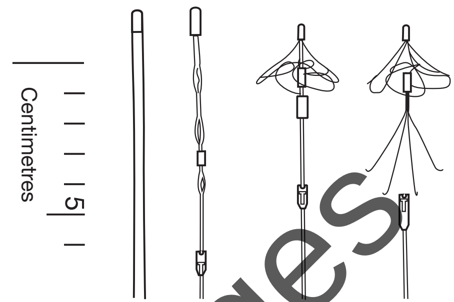


Figure 1.7.1 Stages in placement of a Nitinol filter inside an artery. The left image shows how the device looks when it is inside the catheter (the tube that is pushed into the artery). The next two images show stages of the filter warming up and expanding. The right-hand image shows the filter fully expanded and the catheter being withdrawn at the bottom.

Nitinol is also used to seal off holes between the atria of the heart. The device is pushed through the vena cava, a large blood vessel leading into the heart. The device is composed of SMA wires and a waterproof film of polyurethane. The wires go back to their original shape as they warm, and this closes the hole. The heart tissue gradually grows over the device, completing the repair. A Nitinol septal occluder is shown in Figure 1.7.2.

SMAs are also used as stents, to keep tubes such as blood vessels, the oesophagus and the urethra open. A Nitinol stent in an artery is shown in Figure 1.7.3. SMAs are also used in bone surgery to hold bones together. The SMA wires are kept cold until placed in the body. When they warm up, they tighten and pull the bones together. Shape memory alloys are used in dentistry to make braces. These exert a constant force on the teeth to keep them in place.

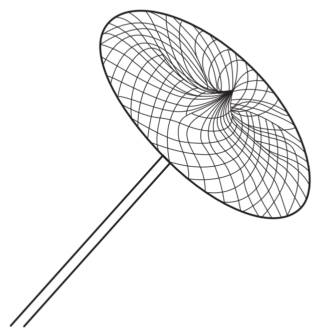


Figure 1.7.2 A septal occluder is a device used to repair a hole between the pumping chambers of the heart. The occluder is made of a Nitinol wire mesh that is shaped into two flat discs and a middle, or 'waist', to fit the defect size. It has polyurethane fabric inserts to help close the hole.

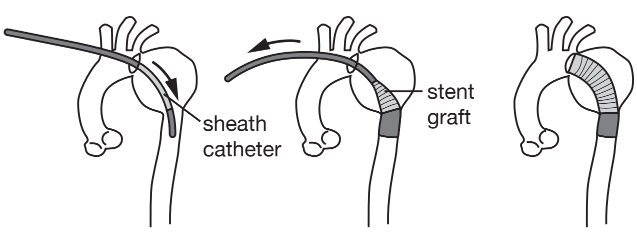


Figure 1.7.3 Placement of a Nitinol stent inside an artery which is swollen and in danger of bursting

1 **Explain** why Nitinol is suitable for surgical use.

2 **Describe** how Nitinol filters are useful in blood vessels.

3 **Describe** the form a Nitinol blood filter takes when at body temperature.

4 **Explain** what has to be done to a Nitinol blood filter to be able to push it into an artery.

5 **Describe** how a Nitinol blood filter is opened out.

6 **Describe** the purpose of Nitinol septal occluders.

7 **Explain** how a septal occluder works.

8 **List** two body tubes kept open by SMAs in surgery.

9 **Explain** how SMAs can be used in bone surgery.

1.8 Space-age aircraft

ADDITIONAL

Knowledge and understanding

L Literacy CCT Critical and creative thinking

Composite materials are now widely used in aircraft. Some typical properties of composite materials, such as carbon fibre-reinforced plastics (CFRP), are high strength, good rigidity and low weight. These composite materials are resistant to corrosion, do not expand much on heating, and are also resistant to cracking when vibrated. These properties make them ideal for use in aircraft bodies.

In aircraft, the main advantage of composites over traditional metals such as aluminium is that composites have a lower weight. For example, a composite is about 20% lighter than aluminium. In aircraft, weight is the major factor affecting how much fuel is used and how many passengers can be carried. These factors can affect the profitability of the airline.

High corrosion resistance is vital in an aircraft. Corrosion destroys the structure and strength of a material and can lead to it breaking under stress. This would be a disaster in the air.

Resistance to snapping when continually being stressed is very important in aircraft. Aircraft vibrate and flex a great deal. Landing is particularly stressful, as is encountering turbulence in the air. Failure of a material under these stresses is called fatigue.

The position where composites are used on an aircraft depends on the properties needed by that part of the aircraft. Composites can be made when other materials are added to the basic carbon fibre. Materials, for example Kevlar, give the structure different properties such as greater fracture toughness and impact resistance. These properties are useful in areas of the plane that could suffer an impact such as hitting a bird in flight. The addition of carbon fibre plastics to fibreglass structures provides extra stiffness to areas such as the wings, which need to resist flexing too much.

1 **List** six properties of CFRP that make it suitable for use in aircraft bodies.

____

____

____

2 **Account** for the increased use of composites in aircraft bodies.

____

____

3 **Explain** why corrosion resistance is vital in aircraft.

____

____

4 **Account** for the need for materials that can withstand stress in aircraft.

5 CFRP has some disadvantages in certain parts of an aircraft such as the leading edge of the wing, the nosecone and the leading edges of the tailplane. **Discuss** the deficiency of CFRP in these parts of the plane.

6 Consider your answer to question 5 above. **Describe** a solution to this problem that involves still using CFRP.

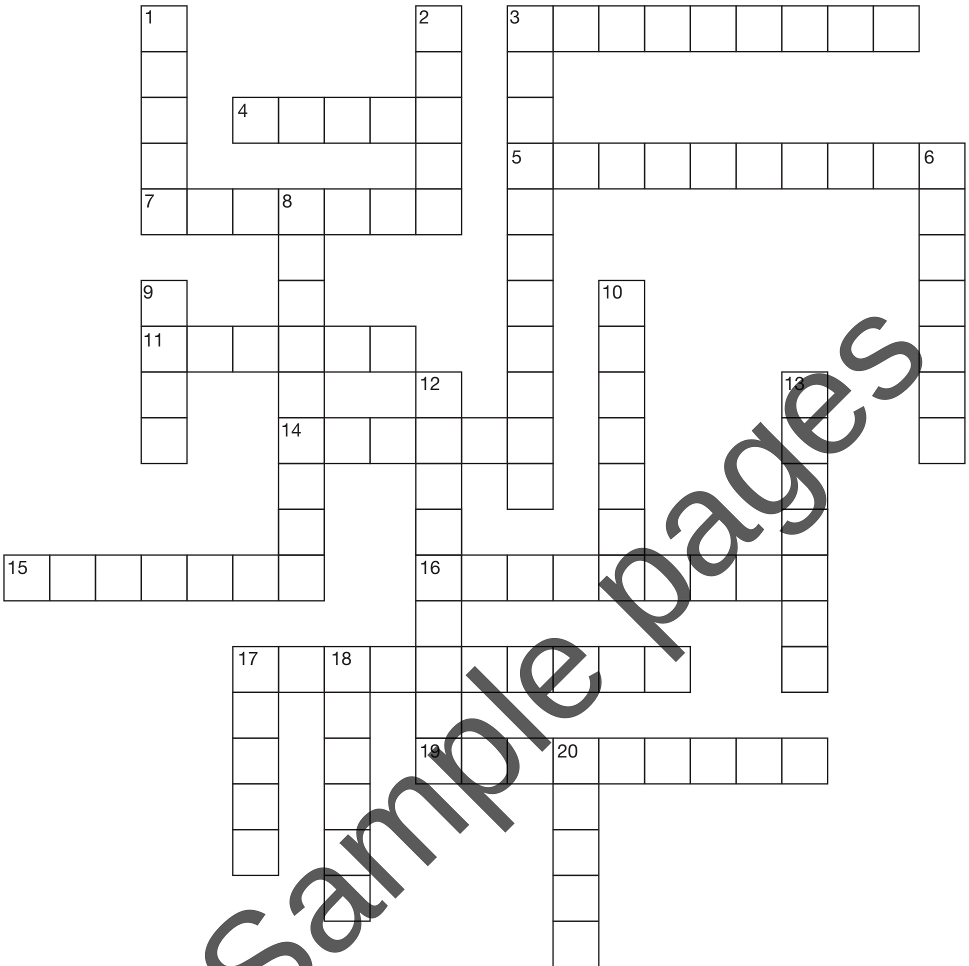
7 Recent research has found that CFRP can suffer from moisture absorption. There was a case of an aircraft that lost the rudder from the tailplane. The cause was identified as water entry into fine cracks in the composite material. The water froze inside the rudder as the plane climbed higher, causing the rudder to explode in the air. **Propose** what could have caused the rudder to explode as the plane climbed higher.

8 One response of materials scientists to the observation that water can enter CFRP components is to make composite materials containing metal. The composite is called MFL, metal fibre laminate. These have an outer layer of metal and then alternating layers of CFRP and metal. **Propose** how MFL overcomes the problem of moisture entry to CFRP.

Knowledge and understanding

L Literacy

Recall your knowledge of materials to complete this crossword puzzle.



Across

3 The ions formed by a base
4 Any substance that can be twisted into a rope or woven or knitted into fabric
5 Name of the scientist who used gold foil to prove the atom to be largely empty space
7 A shape memory alloy
11 A positive ion
14 A base that dissolves in water
15 Molecules made of repeating units
16 Able to be hammered into new shapes
17 Different forms of carbon
19 Particles that spin around the atom in a region of largely empty space

Down

1 A negative ion
2 An iron–carbon alloy
3 Water-hating
6 Able to be stretched into wires
8 A substance that shows whether another substance is acidic, neutral or basic
9 A substance that releases hydrogen ions
10 Shatters if hit
12 One-billionth of a metre
13 Core of the atom
17 Base metal mixed with small amounts of other elements
18 Turns red in the presence of acid, blue in a base
20 The purity of gold is measured this way