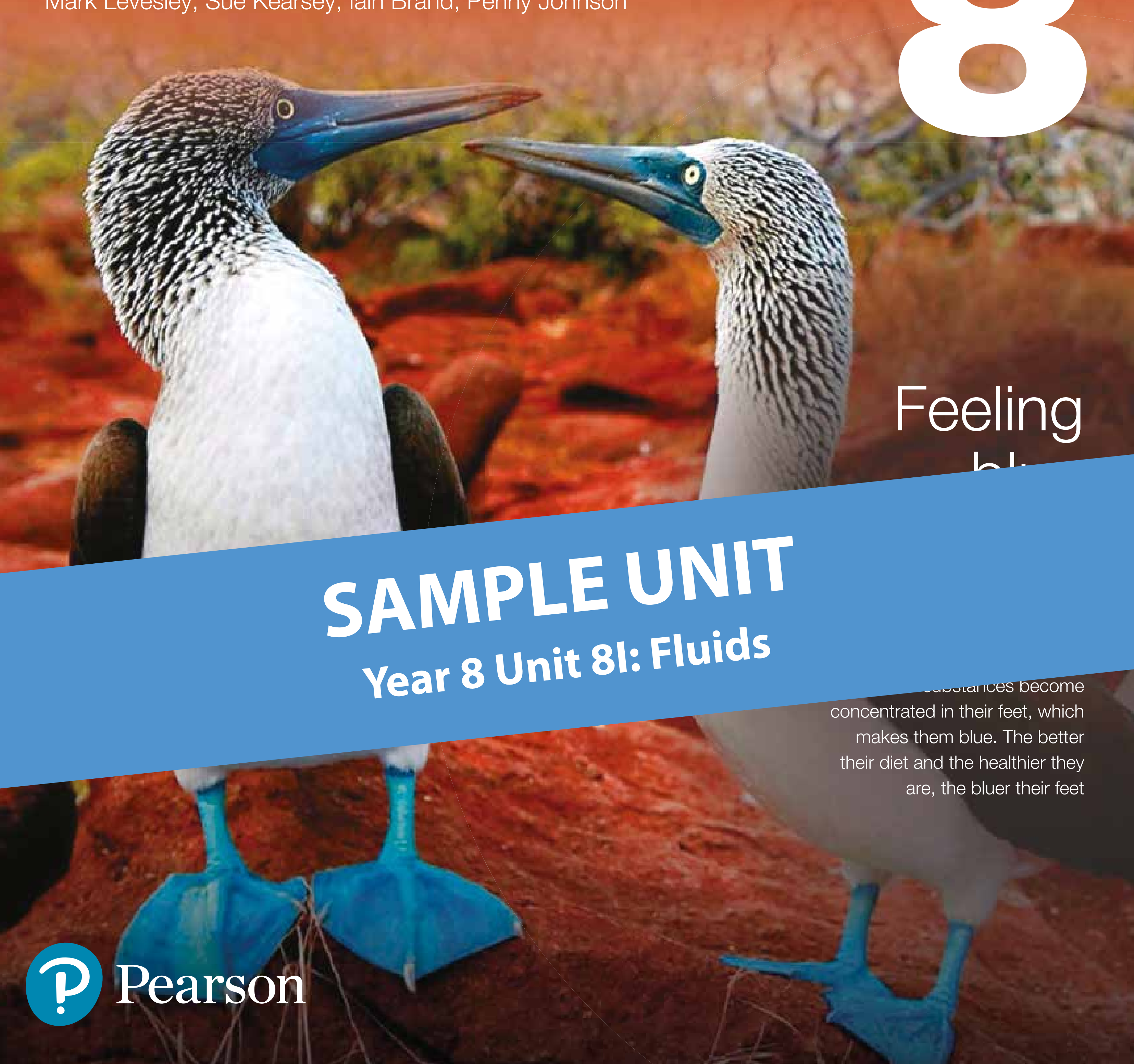
# EXPLORING SCIENCE

## INTERNATIONAL 11–14

# 8

Mark Levesley, Sue Kearsey, Iain Brand, Penny Johnson



Feeling

ubstances become concentrated in their feet, which makes them blue. The better their diet and the healthier they are, the bluer their feet

## SAMPLE UNIT

### Year 8 Unit 8I: Fluids

Pearson

# 8Ia EXPLORING EXTREMES

Exploring extreme environments can help scientists to find out how the Earth and the Universe work. And humans have always wanted to explore new places just to see what is there.

About 70 per cent of the Earth's surface is covered in water. Scientists investigating the ocean floors need to use special technology to allow them to breathe and to cope with the much greater forces on objects underwater.

We can explore the solid surface of the Earth more easily, but technology helps here too. The South Pole was first visited in 1911 using teams of dogs to pull sledges. Today scientists get there using aeroplanes or vehicles fitted with caterpillar tracks. They can live there all year round, even during the Antarctic winter when the Sun never rises.

**A** | James Cameron's *Deepsea Challenger* has gone over 11 km down in the ocean where the forces on it are over 1000 times bigger than on the surface.


**B** | This is Halley station in Antarctica. The snow here never melts. To prevent the station from becoming buried, the buildings can be raised higher each year.

**C** | Astronauts need spacesuits to survive the vacuum of space.

Astronauts exploring the Moon brought back rocks that helped us to learn how the Solar System formed. Experiments in space can help to develop new materials and medical treatments.



**1** Matter can exist as a solid, liquid or gas. Which state of matter is:

a| snow
b| air
c| the water shown in photo A?

**2** Solids, liquids and gases have different properties. How are they different in terms of:

a| shape
b| volume?

**3** Suggest some of the problems that people need to overcome in:

a| photo A
b| photo B
c| photo C.

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# 8Ia THE PARTICLE MODEL

## HOW DO WE EXPLAIN THE PROPERTIES OF SOLIDS, LIQUIDS AND GASES?

Photo A shows a scientific expedition living on the frozen Arctic Ocean to study energy transfers. Ships are normally designed to be used on liquid water, but the ship in photo A has been specially designed to remain undamaged by the forces from solid water.

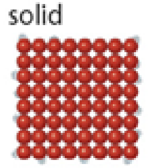
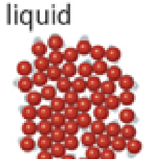
Materials can exist in three **states of matter**: solid, liquid or gas. The properties of a material are different in each of the three states.

- **Solids** keep their shape and volume; they cannot flow and are difficult to **compress** (squash into a smaller volume).
- **Liquids** keep their volume but not their shape; they can flow, take the shape of their containers and are difficult to compress.
- **Gases** can change their shape and volume; they spread out in all directions and are easy to compress.


A | the icebreaker *Xue Long* ('ice dragon') frozen into the Arctic ice

1. Name three different:
   a| solid materials b| liquids c| gases.
2. Write down one similarity and one difference between the properties of:
   a| solids and liquids
   b| liquids and gases.
3. How does the arrangement and spacing of particles explain:
   a| why it is difficult to compress solids and liquids
   b| why gases are easily compressed?
4. How do the forces between particles explain:
   a| why solids keep their shape
   b| why gases expand to fill their containers?

The properties of the different states can be explained using the **particle theory** or **particle model**. This states that all matter is made up of moving particles held together by forces of attraction. The particles can be atoms or molecules. Table B shows how the forces and movement are different in the three states.

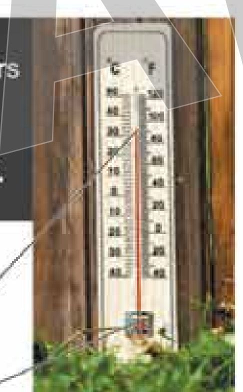
| State | Forces | Spacing | Movement |
|---|---|---|---|
| solid  | strong | close | vibrate in fixed positions |
| liquid  | fairly strong | close | move around within the liquid |
| gas  | weak | far apart | move about fast in all directions |

B

Scientists think the particle model is correct because it explains many observations.

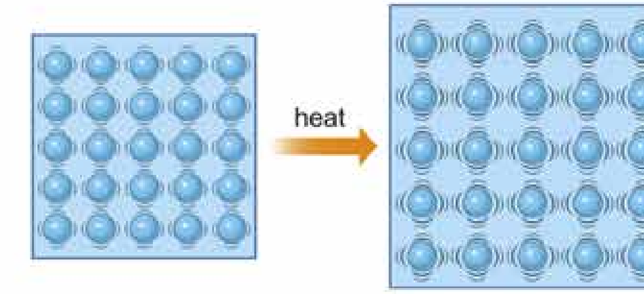
- **Diffusion**: gases or liquids mix without anything moving them because the particles are moving around all the time.
- **Brownian motion**: tiny bits of dust in air or water can be seen jiggling around around as they are hit by the moving air or water particles.
- **Expanding** and **contracting**: materials expand when heated and contract (get smaller) when cooled. This is because the particles in hotter materials move faster and so take up more space.
- **Density** changes: density is the **mass** of a certain **volume** of a material. When a material contracts, its density increases, because the same mass of particles takes up a smaller volume. A material's density decreases when it expands.

Buildings, bridges and other structures change size all the time. They have to be built with gaps in, so that, if the materials in them expand, the structure does not bend or break.




E | Many thermometers use the expansion of a liquid to provide temperature readings.

F | an expansion joint in a bridge




C | When a solid is heated the particles vibrate further about their fixed positions. The particles themselves do *not* change size.

5. A substance cools down when energy is transferred away from it. Explain how this affects:
   a| the movement of the particles
   b| the size of the object.

**FACT**

Train tracks can buckle and twist in very hot weather.

D

6. Look at photo E.
   a| Explain how a thermometer works.
   b| Suggest how you could make your own thermometer.
7. A bridge is built without expansion gaps. Explain what could happen to the bridge if the temperature became:
   a| much hotter than the day it was built
   b| much colder than the day it was built.

### I can ...

- describe the properties of different states of matter
- explain the properties in terms of the particle model
- explain why materials expand and contract when the temperature changes.

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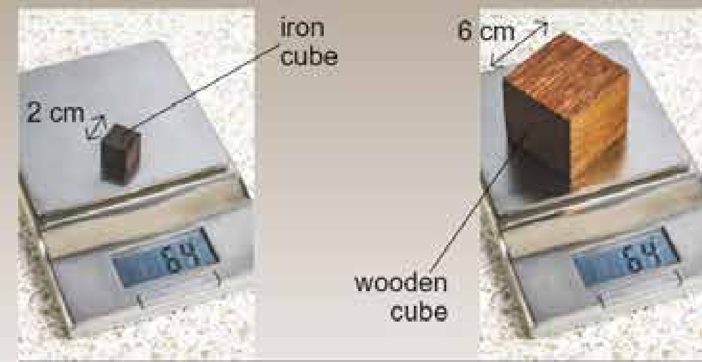
# 8la CALCULATIONS WITH DENSITY

## HOW CAN WE FIND THE DENSITY OF AN OBJECT?

Photo A shows a piece of wood and a piece of iron that both have the same mass. People often say that metals are heavier than wood, but this is not correct. They usually mean that a piece of metal will have a greater mass than *the same sized* piece of wood. The mass of a piece of material with a volume of 1 $cm^3$ is the density of the material.


**B | When the water is heated its mass does not change but its volume increases. This means that its density decreases.**




**A | The two cubes have the same masses but different volumes, so their densities are different.**

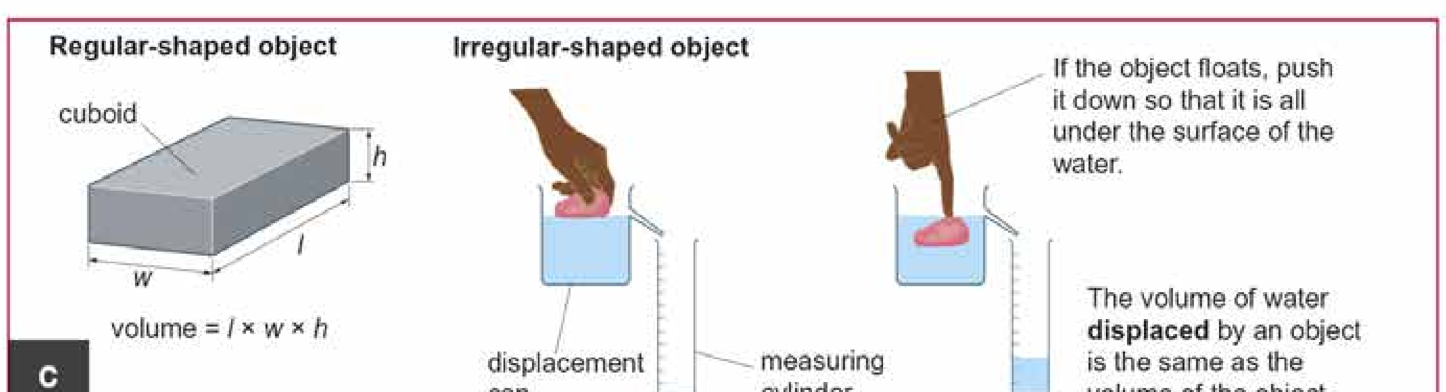
If the volume of an object changes without its mass changing (usually because it has been heated or cooled) its density will change.

Density is a quantity that cannot be measured directly. It has to be calculated using measurements of mass and volume.

## Measuring volumes

Diagram C shows two ways of finding the volume of an object.

Volumes can be measured in metres cubed ($m^3$) or centimetres cubed ($cm^3$). These can sometimes be called cubic metres or cubic centimetres. Some measuring cylinders have the scale marked in millilitres (ml). One millilitre is the same volume as one centimetre cubed.




C

**1** A piece of metal is a cuboid with width 2 cm, length 5 cm and height 1.5 cm. Calculate its volume.

**2** Describe how to measure the volume of a piece of modelling clay.

# WORKING SCIENTIFICALLY

## Calculating density

The formula for calculating density is:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Scientists often use *ρ* (the Greek letter rho, pronounced *'rowe'*) to represent density. We will use the letter 'd' instead.

This can be written in symbols as $d = \frac{m}{V}$

The units for density can be kilograms per metre cubed ($kg/m^3$) or grams per centimetre cubed ($g/cm^3$), depending on the units used for measuring the mass and volume. A worked example is shown on the right.

**3** Calculate the density of the piece of iron shown in photo A.

### Worked example

The volume of the wooden cube in photo A is:

6 cm × 6 cm × 6 cm = 216 $cm^3$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$= \frac{64}{216}$$

= 0.296 $g/cm^3$

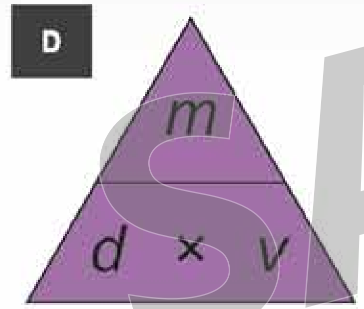
= 0.3 $g/cm^3$ (when rounded to 1 decimal place, 1 dp)

## Calculating mass or volume

Sometimes a question may give you the mass and density of an object and ask you to calculate its volume.

The triangle in diagram D shows you how to rearrange the formula.

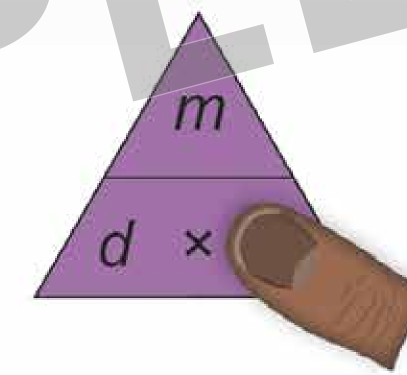
D




Cover the quantity you want to calculate, and what you can see is the formula you need.

So, the formula for calculating volume is:

$$\text{volume} = \frac{\text{mass}}{\text{density}}$$




You can also use the triangle to show how to calculate mass if you know the density and volume:

mass = density × volume

**4** The density of aluminium is 2.7 $g/cm^3$. You have a piece of aluminium with a volume of 50 $cm^3$.

a| Write down the formula you need to use to calculate its mass.

b| Work out its mass.

c| What is the volume of 810 g of aluminium?

**5** A swimming pool contains 2500 $m^3$ of water with a density of 1000 $kg/m^3$ at 10° C. The water in the pool is heated to 20 °C and expands by 5.25 $m^3$.

a| Calculate the mass of the water in the swimming pool at 10 °C.

b| Use the particle model to explain why the water expands.

c| Will the density of the water increase or decrease when it is heated? Explain your answer.

d| Calculate the new density of the water after it has been heated.

### I can ...

- state what is meant by density, and recall its units
- describe how to measure the volume of irregular objects
- use the formula relating mass, volume and density.

# 8Ib CHANGING STATE

## HOW DO MATERIALS CHANGE FROM ONE STATE TO ANOTHER?

**Melting** and **freezing** are **changes of state**. Some materials (including ice in some conditions) can change directly from a solid to a gas. This is called **sublimation**.

Changes such as combustion and neutralisation are **chemical changes**, because the atoms within substances become combined in different ways to form new substances. Changes of state are **physical changes**, because the chemicals in the substances do not change.

If you heat a solid to its **melting point** it forms a liquid. Particles can **evaporate** from the surface of a liquid to form a gas at any temperature. The **boiling point** of a substance is the temperature when evaporation happens *within* the liquid. The bubbles in **boiling** water are bubbles of **water vapour**.

If you cool a gas, it **condenses** into a liquid. If you cool a liquid, it starts to turn into a solid when the temperature reaches its **freezing point**. The freezing point and melting point of a substance are always the same temperature.

Graph B shows temperature against time for heating a **pure** substance. A mixture changes state over a range of temperatures because it contains substances with different melting and boiling points.

Energy is needed to overcome the forces holding particles together when solids change into liquids. When a liquid turns back into a solid, this energy is no longer needed and is transferred to the surroundings. The temperature of the substance remains the same while the liquid is changing to a solid.

**3** Look at graph B.

a| What is the melting point of the substance shown in the graph?

b| What is its boiling point?

c| Why does the temperature of the substance stop rising at point X?

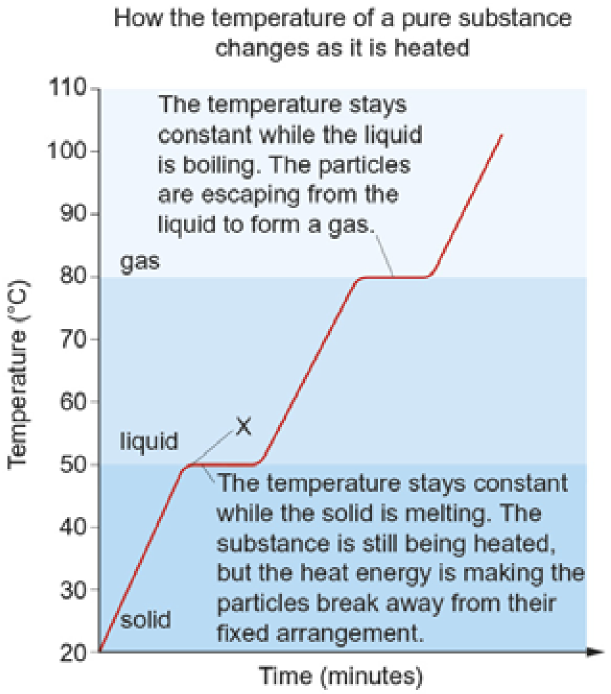
d| Sketch a similar graph to show what happens when a substance cools down. Add a title and labels to explain the shape of your graph.

A | an iceberg melting

**1** In degrees Celsius (°C), at what temperature does:

a| ice melt b| water freeze?

**2** Explain why diffusion is a physical change.



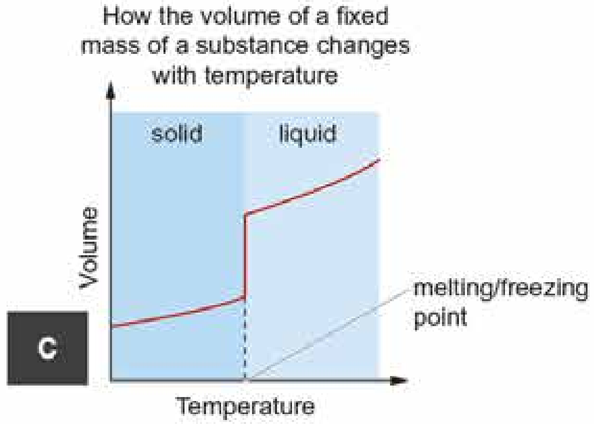

B

A solid expands when it is heated and it expands even further when it forms a liquid. Graph C shows how the volume of a substance changes with temperature.

**4** Think about graph C.

a| Explain why the volume of a substance increases as it gets warmer.

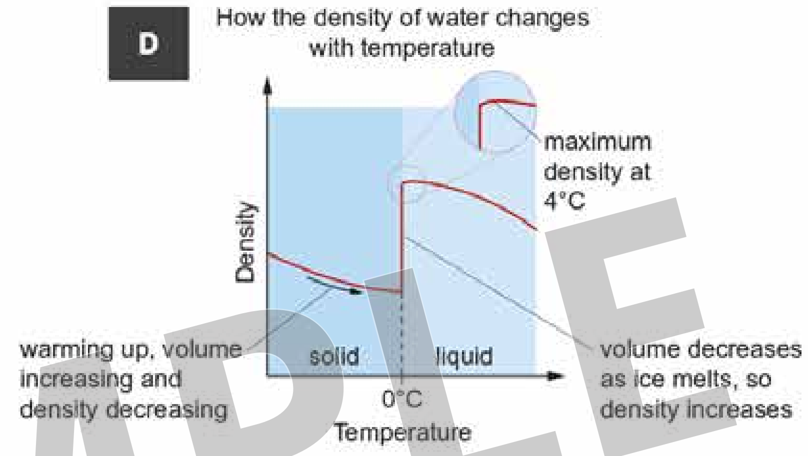
b| Describe how the volume of 1 kg of molten iron changes as it cools down and forms a solid.




C

Water shows **anomalous** behaviour near its freezing point. This means that it does not behave in quite the same way as other materials. As water cools down it contracts until it reaches 4 °C and then it starts to expand again slightly. When ice forms, the ice takes up more space than the water did. Ice is less dense than water. This is why ice forms on the tops of ponds, which helps fish and other organisms to survive.

D




E | Water freezing inside this jar has expanded and split it apart.

**FACT**

This boulder was split by water getting into its cracks and expanding as it froze.

F

**5** a| Explain the shape of the line on graph D.

b| Describe two ways in which the changes shown in graph D are different from the changes that would occur in the case of a substance such as iron.

**I can ...**

- recall that a substance does not change temperature while it is changing state
- describe what happens to particles during changes of state
- describe the ways in which water and ice are different from other liquids and solids.

# 8Ic PRESSURE IN FLUIDS

## HOW DO FLUIDS EXERT PRESSURE?

The particles in **fluids** (liquids and gases) are moving around in all directions. As they move they bump into each other and any surfaces they come into contact with. The force of the particles hitting things causes **pressure**. Pressure in liquids and gases comes from all directions.

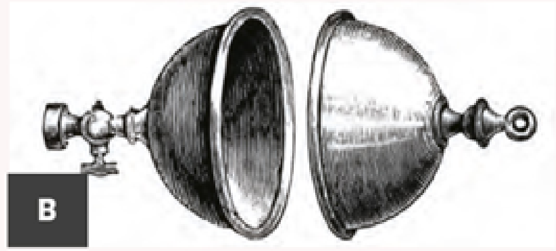
Atmospheric pressure (the pressure of the air) at the surface of the Earth is about 100 000 pascals. One pascal (Pa) is a force of one newton on every square metre. We do not notice this pressure because fluids inside our bodies are at a similar pressure.

Car and bicycle tyres contain air under high pressure. The pressure inside is high because extra air has been pumped into the tyre so there are more particles to hit the inside walls of the tyre.

Pressure in fluids increases as the temperature increases, because the particles move faster and hit the walls of the container harder. If you compress the same amount of gas into a smaller volume the pressure also increases, because the particles hit the walls more often.

**1** What causes pressure in fluids?

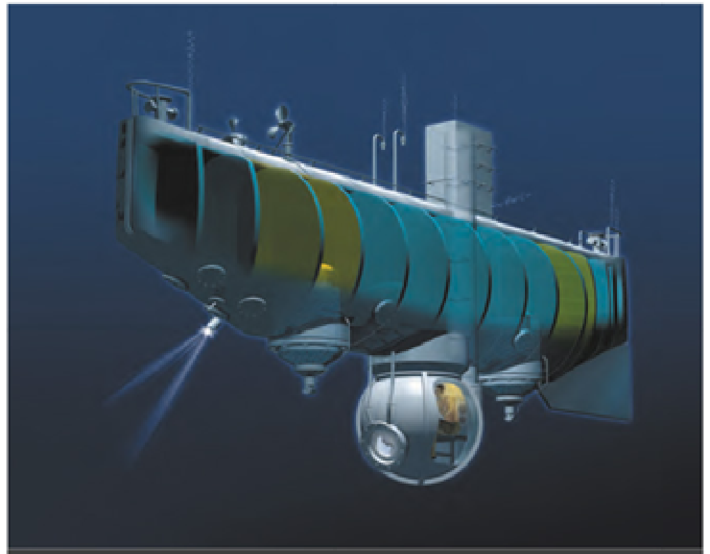
**2** Look at photo B. Explain why the two hemispheres cannot be pulled apart when some of the air has been sucked out of the space between them.



B

**3** Give two ways in which the pressure of a fluid can be increased. Explain your answer.

**A** | People diving for fun usually stay within 30 m of the surface. People who work further below the sea need special suits, like this one, to stop the high pressure from the water harming them.



**C** | This cutaway drawing shows the *Trieste* submersible, which set the record for the deepest dive in 1960. Two men travelled in the pressure sphere underneath the flotation tanks.

**FACT**

**The deepest part of the ocean is the Challenger Deep, nearly 11 000 m below sea level. More people have walked on the Moon than have visited the lowest place on Earth!**

Pressure in a fluid depends on the weight of fluid above. As you go down into the ocean there is more water above you and the pressure increases. The surface of the Earth is at the bottom of the atmosphere. If we go up a mountain there is less air above us and so the pressure gets less. There are fewer particles in each metre cubed of air.

**D** | Mountaineers need to carry tanks of oxygen with them to help them to breathe at high altitude. Without oxygen, they may suffer from altitude sickness and could die.

This photo was taken at a height of 2413 m.

This is the same bag of crisps at sea level.

**E** | These photos demonstrate the effect of air pressure on a sealed bag of crisps.

**4** a| Use ideas about particles to explain why there is less pressure on you from the air if you go up a high mountain.

b| Explain why the mountaineer in photo D needs to wear an oxygen mask.

**5** Look at the photos in E. Explain why the bag looks different in the two photos, using ideas about particles and pressure.

**6** The steel walls of the pressure sphere on the *Trieste* (photo C) were over 12 cm thick. This is much thicker than the steel that ships are made from. Explain why the walls needed to be so thick.

**7** A diver will experience twice atmospheric pressure by descending just 10 m below the surface of the sea, but you need to climb over 5000 m above sea level before air pressure is halved. Explain this statement in as much detail as you can.

**I can ...**

- describe how fluid pressure changes with depth or height
- describe how gas pressure can be increased
- explain some effects of pressure in different situations using the particle model.

UK NC, iLS, CEE

# 8Id FLOATING AND SINKING

## WHY DO SOME THINGS FLOAT AND SOME THINGS SINK?

The first boats used by humans were probably just tree trunks dug out to make canoes. Later, pieces of wood were shaped and fixed together to make ships. The first ship made out of metal was not built until 1860.

When you are standing on the ground, gravity is pulling you down. An upwards force from the ground stops you sinking into the Earth. When you float in water, you feel that you weigh less. This is because there is a force from the water called **upthrust**. This pushes up against your **weight**. You still have weight, but you do not feel it. An object will float when the upthrust balances its weight.

**1** a| What two forces affect you when you float?

b| How do these two forces compare in size?

**2** A boy's weight is 500 N. What upthrust does he need to float?

**3** A hot air balloon is floating in the air. The air gives upthrust.

a| What are the two forces acting on the balloon?

b| What can you say about the sizes of the two forces?

**A** | Viking explorers were the first Europeans to visit North America, using wooden longships like this replica.

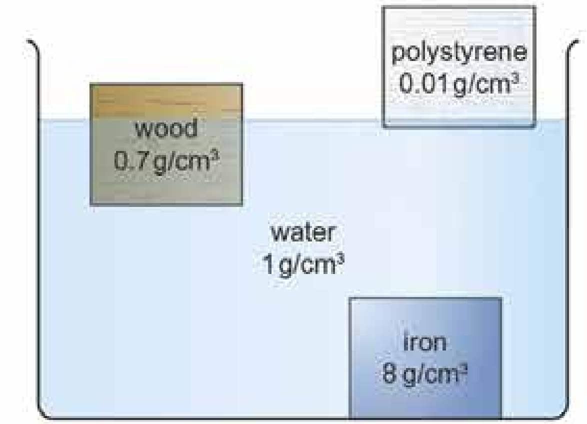
There is always upthrust on an object in a fluid, even if the upthrust is not large enough to make the object float. Photo B shows one way of measuring the upthrust.

**4** Look at photo B. Describe how you can measure the upthrust on an object.

**5** How could you find out if the size of the upthrust depends on the material the object is made from?

You can work out if something will float in a fluid if you know its density and the density of the fluid. The density of water is 1 g/cm³. If something has a density less than 1 g/cm³ it will float in water. For objects that float, the greater their density the more of the object is under the water.


**B** | measuring upthrust

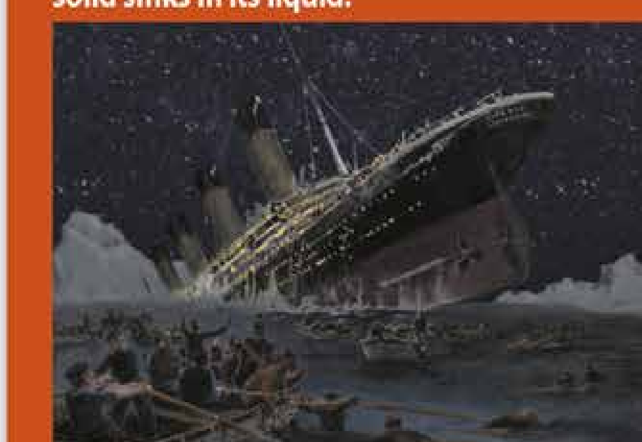



**C** | Objects less dense than water float in water. The lower an object's density, the higher out of the water it floats.

The density of air at sea level is approximately 0.001 g/cm³. Hot air balloons fly because the overall density of the whole balloon (including the basket and passengers and the hot air inside it) is less than the air around it. The air inside is heated to make it expand and become less dense.

### FACT

**Icebergs float with about 90 per cent of their volume under the surface of the water. This means that a ship sailing close to ice may hit part of the iceberg that the crew cannot see. Ice is unusual because with most materials a solid sinks in its liquid.**



**E** | The RMS *Titanic* sank in 1912 after it hit an iceberg.

**D** | The pilot can make the balloon rise higher by making the air inside the balloon hotter.

**6** Look at diagram C.

a| Explain whether a cube of iron will float in mercury (the density of mercury is 13.6 g/cm³).

b| Explain why polystyrene will float in water but not in air.

**7** Steel is denser than water, so how can a steel ship float? (*Hint*: think about what is inside the ship.)

**8** Look at photo D. Explain why making the air inside the balloon hotter makes the balloon rise. Use ideas about particles in your answer.

### I can ...

- state what is meant by upthrust
- explain why some objects float
- recall the factors that affect the amount of upthrust
- use ideas about density in my explanations.

# 8Ie DRAG

## WHAT IS DRAG AND HOW CAN IT BE REDUCED?

Any object moving through water or air will have a resistance force on it that will slow it down. **Water resistance** and **air resistance** are types of **drag**.

**1** What is drag?

The drag on a moving object is partly caused by **friction** between the moving object and the fluid. This friction can also cause the moving object to heat up. This part of the drag is reduced by giving the object a smooth surface.

Some of the drag is caused because the object has to push some of the fluid out of the way. The faster the object is moving, the more fluid has to be pushed out of the way each second. This part of the drag is reduced by keeping the area that faces the moving air or water as small as possible, and by giving the object a **streamlined** shape. This makes it easier for the fluid to move around it.

**A** | The parachutes on these crates have a large area, so they produce a lot of drag.

**B** | This submarine has a top speed of approximately 65 km/h and a crew of 140.

**C** | The submersible *Alvin* is used for scientific exploration of the sea bed. Its top speed is just over 3 km/h and it has a crew of two.



**2** Write down three ways of reducing drag.

**3** Look at photo A. Why do the parachutes need to have a large area?

**4** Look at photos B and C. Compare the features of the two vehicles that will affect their drag.

The amount of drag on a moving object depends on its speed as well as its shape. The faster the object is moving, the greater the drag.

A vehicle travelling at a steady speed has **balanced forces** on it. A forwards force from the engine is needed to balance the drag forces. If the drag is less, the vehicle will not need such a big force from the engine to travel at that speed, and it will not use up as much fuel.

The top speed of a vehicle depends on the force its engine can produce and on the drag. As the vehicle goes faster and faster the drag increases until eventually it is as big as the maximum force from the engine.

**E** | a competitor in the Asian Track Championships in 2018

### FACT

Golf balls have small dimples on their surface to reduce drag.

**D** | Drag also occurs when a fluid is moving past an object. This car is in a wind tunnel. It is not moving, but air is being blown past it. The smoke helps to show how the air flows over it.

**5** Athletes often need to make their drag as small as possible.

a| Describe two ways in which the cyclist in photo E has reduced his drag.

b| Explain how reducing his drag helps him to go faster.

**6** a| Why do objects heat up if they are moving fast?

b| Use ideas about particles to explain why the drag is less if an object is moving slowly.

**7** Write a 20-second radio advert explaining to drivers why they should drive more slowly.

**8** a| Suggest two ways in which a car designer could increase the top speed of a new car.

b| Explain why each way would work, using ideas about balanced forces.

**9** Suggest why the water speed record is only 511 km/h when the land speed record is 1227 km/h.

### I can ...

- describe ways in which drag forces can be increased or reduced
- describe the causes of drag forces
- describe how drag changes with speed.

# 8Ie OPERATING AEROPLANES

## WHAT SKILLS ARE NEEDED TO OPERATE AEROPLANES?

There are nearly 10 000 aeroplanes in the air at any one time, carrying over a million passengers. Airline pilots are responsible for the safety of billions of passengers each year.

B | Pilots need to be able to think quickly. This aeroplane's engines stopped working soon after take-off. The pilot landed in a nearby river and everyone survived.

Pilots must be good at maths and physics and must pass strict medical tests. As well as learning to fly, the training at flight schools includes meteorology (weather), navigation, air law and how aeroplanes work. Their pilot's licence must be recognised by all the countries they fly to.

## Air traffic control

Air traffic controllers tell pilots where they can fly, to make sure there are no collisions. They need to study many of the same things as pilots in their training.

3 Suggest why air traffic controllers need to study meteorology.

Communications between air traffic control and pilots are made in English, so pilots and controllers must speak English well. There are also internationally agreed conventions they use to make sure people understand.

A | Pilots must understand and use many different instruments and displays in the cockpit.

1 Suggest why pilots need to study:
a | meteorology
b | navigation.

2 The aeroplane in photo A is an Boeing 737. Suggest why the two pilots would have to do more training before they fly an Airbus A320.

C | Air traffic controllers use radar and computer technology to help them to keep aeroplanes at safe distances from each other.


D | talk between a pilot and air traffic control

4 Why do maps for pilots show things like radio masts?

5 Explain why the wheels are moved inside the aeroplane after take-off.

6 Airliners fly at a height of about 12 km. Explain why they must have pressurised cabins and breathing masks that provide the passengers with oxygen if the cabin becomes depressurised.

Maps for pilots and air traffic controllers have internationally agreed symbols on them to show things like navigation aids, routes, and obstacles such as tall masts or buildings. They need to be able to understand charts like these.

E | Maps used by pilots use special symbols.

## ACTIVITY

Pilots and controllers need to understand how aeroplanes fly, so they can work out things like the length of runway a particular aeroplane will need to take off. This information is often presented as charts or graphs.

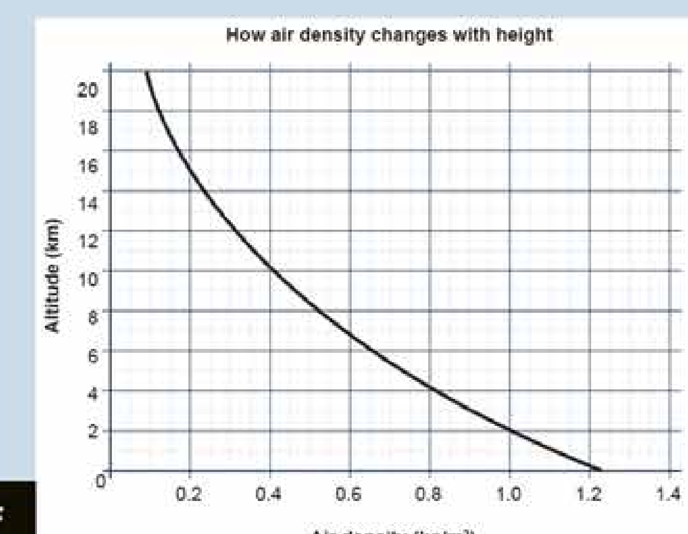
The upwards force on an aeroplane's wing is called lift. The lift produced by a wing is proportional to the density of the air. The lift also depends on speed – the faster an aeroplane is flying, the greater the lift.

Graph F shows how air density changes with height. Air density also depends on temperature. Hot air is less dense than cold air.

1 Compare the density of the air at 12 km with the density at sea level.

2 Explain how the lift from a wing changes when an aeroplane:
a | slows down
b | climbs to a greater height.

3 Explain why an aeroplane has a higher take-off speed on a hot day.




F

# 8Ie HUMANS AT THE EXTREMES

## HOW CAN WE SURVIVE IN EXTREME CONDITIONS?

In 2012, Felix Baumgartner broke the world record for skydiving. He jumped from a balloon at about 39 km above the Earth and reached supersonic speeds as he fell. This is also the record for the highest balloon flight. He needed to wear a special pressure suit to keep him alive.

A | Baumgartner's jump being watched from mission control.

**1** As Baumgartner's balloon went up through the atmosphere, it got bigger. Explain why this happened, using ideas about particles and pressure.

Divers exploring the oceans used to suffer from decompression sickness. Experiments on animals and humans allowed scientists to work out safe ways of reducing the pressure as they came back to the surface so that divers would not be harmed.

People who work on boats in the Arctic or Antarctic often wear immersion suits. These help them to survive for longer if they end up in the water. This gives them more chance of being rescued. Some of the information used to develop these suits was obtained from experiments on human prisoners.

B | An immersion suit helps a person to survive in cold water.

**2** a| Name one substance in each state of matter in photo B.
b| Describe the arrangement and movement of particles in each state.
c| How does the particle model explain the properties of the three states?

**3** Sketch a graph to show how the temperature changes with time when a piece of ice is left to melt in a warm room. Label your graph to explain what is happening to the particles.

**4** In photo B, ice is floating on liquid water. Explain why this is unusual. Use ideas about particles and density in your answer.

## HAVE YOUR SAY

**Should experiments ever be carried out on animals? Should they be carried out on humans?**