Name ______________________ Class ____________ Date ____________

These statements are about solids, liquids and gases. Some of them are not correct.

1 Tick (✓) the boxes to show if they are true or false. Then write correct versions of the false statements.

		True	False
a	You can pour solids and liquids, but not gases.	☐	☐
	______________________________		
b	The particles in gases are further apart than the particles in liquids.	☐	☐
	______________________________		
c	Particles in solids do not move.	☐	☐
	______________________________		
d	Liquids can be compressed because the particles are close together.	☐	☐
	______________________________		
e	When a substance expands the particles in it get bigger.	☐	☐
	______________________________		
f	Particles in liquids and gases can move around.	☐	☐
	______________________________		
g	Particles in a solid vibrate more when the solid is heated.	☐	☐
	______________________________		
h	Particles in liquids and gases move more slowly when the substance is heated.	☐	☐
	______________________________		
i	Gases expand to fill their containers because there are strong forces between the particles.	☐	☐
	______________________________		
j	Solids do not change size when their temperature changes.	☐	☐
	______________________________		

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.

Your teacher may watch to see if you can:

- follow instructions carefully.

Aim: use the idea of liquids expanding to make a thermometer.

Method

Apparatus

- conical flask
- large bowl
- beaker
- crushed ice
- water
- water bath set to 50 °C
- thin bore glass tubing fitted in a bung
- coloured dye
- ruler
- eye protection
- marker pens

⚠ Be very careful with the glass tubing. It can break easily.

Mop up any spills straight away.

A Fill a bowl with crushed ice.

B Put a little coloured dye in the flask, and then fill it to the very top with cold water. Stand it in the bowl of crushed ice.

C After 15 minutes, carefully push the rubber bung into the top of the flask. You should see the coloured water in the glass tube. Mark the level of the water in the tube.

D Put the flask into a water bath and leave it for 15 minutes.

E After 15 minutes, mark the new level of the water in the glass tube.

F Divide the distance between your two marks into five equal divisions. Each division will represent 10 degrees.

G Leave your flask on the bench for 15 minutes (or until the next lesson). Mark the new level of the water.

Considering your results/conclusions

1 **a** What temperature does the bottom mark on your tube represent?

b What temperature does the top mark represent?

c How many degrees does each division represent?

2 What was the room temperature you measured using your thermometer?

3 Why did you only mark 10-degree divisions?

4 How could you work out how much the water rises for each degree?

Evaluation

5 Suggest why this is not a very accurate thermometer.

6 How could you change the thermometer to make it faster to use?

7 Suggest what problems you might have using this thermometer to measure the temperature outdoors in the winter.

I can…

- follow instructions to make a thermometer
- evaluate my thermometer and suggest improvements.

Your teacher may watch to see if you can:
- use measuring instruments correctly.

Introduction

Density measures how much mass there is in 1 cm^3 of something. You have to work it out from a mass and a volume.

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

Aim: To find the density of different solids and liquids.

Method

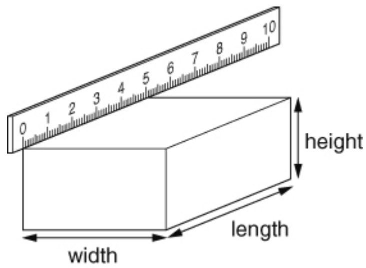
Apparatus
- different solids and liquids
- ruler
- calculator
- bowl
- balance
- measuring cylinder
- displacement can

⚠ Clear up any spilled water straight away.

A For each solid or liquid, write down its name.

B Find the mass of each solid using a balance.

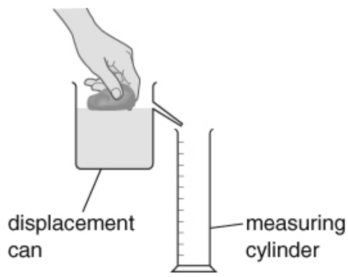
Method – cuboid-shaped solids



C Measure the length, width and height of your object. Work out the volume using the formula: volume = length × width × height.

D Use the mass and volume to calculate the density of the object.

Method – irregular solids

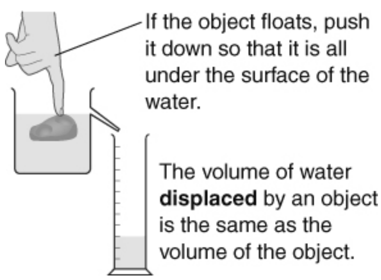


E Stand a displacement can on the bench with its spout over a bowl. Fill it with water until the water just starts to come out of the spout.

F Hold a measuring cylinder under the spout and carefully drop your object into the can. If your object floats, carefully push it down until all of it is under the water. Your finger should *not* be in the water.

G Stand the measuring cylinder on the bench and read the volume of water you have collected. This is the same as the volume of your object. Write it down.

H Use the mass and volume to calculate the density of the object.



Method – liquids

I Put an empty measuring cylinder on a balance, and set the balance to zero.

J Pour 10 cm^3 of a liquid into the measuring cylinder. Write down the reading on the balance. This is the mass of 10 cm^3 of the liquid.

K Use the mass and volume to calculate the density of the object.

Considering your results/conclusion

1 Sam says 'Liquids are less dense than solids.' Use your results to explain whether or not this is correct.

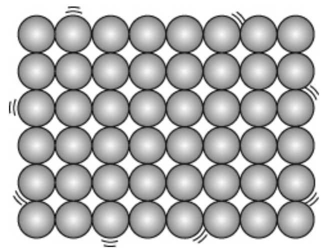
I can…
- use the formula for calculating density.

Name ______________________ Class __________ Date __________

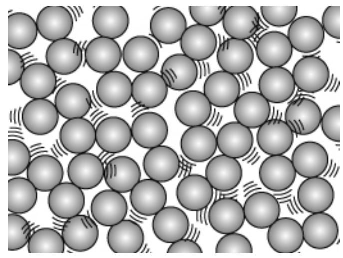
1 Fill in the gaps in these sentences using words from the box. You can use each word once, more than once or not at all.

close together	container	compress	contract	expand	far apart	
gas	liquids	shape	solid	strong	volume	weak

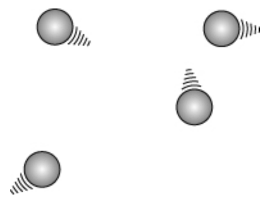
The three states of matter are solids, ______________ and gases.



Solids have a fixed shape and ________________, so they cannot be poured and are difficult to ________________. This is because the particles in solids are ________________ and are held in a fixed arrangement with ________________ forces.



Liquids have a fixed ________________, but they do not have a fixed ________________. They take the shape of their ________________ and they can be poured. The particles are held ________________ by fairly strong bonds, but can move past each other in the liquid.



Gases do not have a fixed shape or volume. They ________________ to fill any container they are in. The particles in a gas are ________________ and there are only ________________ forces between them.

2 A thermometer has a red liquid inside it.

a What happens to the particles in the liquid when the thermometer gets hotter?

____

b How does this affect the volume of the liquid?

____

c What happens to the particles in the liquid when the thermometer gets colder?

____

d How does this affect the volume of the liquid?

____

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.

Density calculations

Name ______________________________ **Class** ___________ **Date** ____________

You will need to use these formulae to answer the questions.

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

1 The table shows some information about different materials. Fill in the missing values, including the missing units.

Material	Mass	Volume	Density
a aluminium	27 g	10 cm^3	_______ g/cm^3
b copper	170 g	_______________	8.5 g/cm^3
c copper	_______________	0.2 m^3	8500 kg/m^3
d ice	_______ g	50 cm^3	0.92 _______
e iron	1560 _______	0.2 _______	_______ kg/m^3
f pine wood	265 kg	_______________	530 kg/m^3
g liquid water	5 _______________	500 cm^3	1 g/cm^3

2 Kayaks have been used for thousands of years to hunt and fish in Arctic regions.

The total volume of a particular kayak is 285 litres (which is 0.285 m^3). It has a mass of 75 kg. The man using it has a volume of 0.066 m^3. When sitting in the kayak, half of man's volume is inside the kayak. The density of the human body is about 1000 kg/m^3.

a Calculate the density of the empty kayak.

b Calculate the mass of the kayaker.

c What is the overall density of the kayak and the kayaker when it is being paddled?

3 The density of materials changes when their temperature changes. The density of water is 1000 kg/m^3 at 0 °C, and is 700 kg/m^3 at 300 °C.

a Calculate the volume of 5 kg of water at 0 °C.

b Calculate the volume of the same mass of water at 300 °C.

c What is the change in volume of 5 kg of water as it is heated from 0 to 300 °C?

I can…

- use the formula relating mass, volume and density.

Changing size 1

Materials expand and contract when the temperature changes. Different materials expand by different amounts for the same temperature increase. The table shows how much longer a 10 m piece of material will get when the temperature rises by 10 °C.

Material	Expansion for a 10 °C increase (mm)
Concrete	11
Glass	10
Steel	11

1 Mr Grey cannot get the lid off a jar. He turns on the hot tap and holds the lid of the jar under the running water.

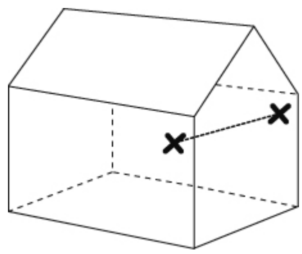
a What will happen to the temperature of the steel lid?

b What will happen to the size of the steel lid? Explain your answer using ideas about particles.

c How will the temperature of the glass jar change compared to the temperature of the lid?

d Explain how this will help Mr Grey to get the lid off the jar. Refer to information from the table in your answer.

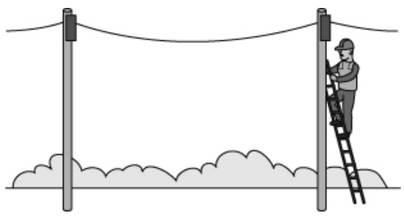
2 The walls in some old houses can bulge outwards a little. If this happens, the house can be strengthened by inserting an iron rod right through the house and screwing ‘anchor plates’ on each end. The centre of the rod is then heated and the anchor plates are tightened up. You can often see the cross-shaped anchor plates on the walls of old buildings.



a What will happen to the iron rod when it is heated?

b The hot iron rod is tightened up, and then allowed to cool down again. How will this help to stop the walls bulging?

3 Workers are installing new telephone wires on a summer’s day.



Someone passing by stops to watch, and tells the workers that the wires are too slack and they should use a shorter length of wire.

Explain why the person is wrong.

4 How does the density of the telephone lines in question 3 change between summer and winter? Explain your answer.

I can…

- explain why materials expand and contract when the temperature changes
- identify some consequences of changing the temperature of an object
- use the particle model to explain density changes at different temperatures.

Engineers and designers need to know how much different materials will expand and contract with temperature changes. The change of size depends on the size of an object, the material it is made from and how much the temperature changes. The table shows how much a one-metre length of a material expands if it is heated up by 10 °C. The expansion (or contraction) is the same whatever the starting temperature, as long as the material does not melt!

You can use the formula in the box below to work out a change in length (you do not need to remember this!)

Material	Length change factor (mm/m/°C)
Brass	1.9
Copper	1.7
Gold	1.4
Iron	1.2
Platinum alloy	0.9
Steel	1.1

$$\text{length change (mm)} = \text{length (m)} \times \frac{\text{temperature change (°C)}}{10} \times \text{length change factor (mm/m/°C)}$$

Example

A 5 m long piece of brass rod is heated from 20 °C to 50 °C. By how much will it expand?

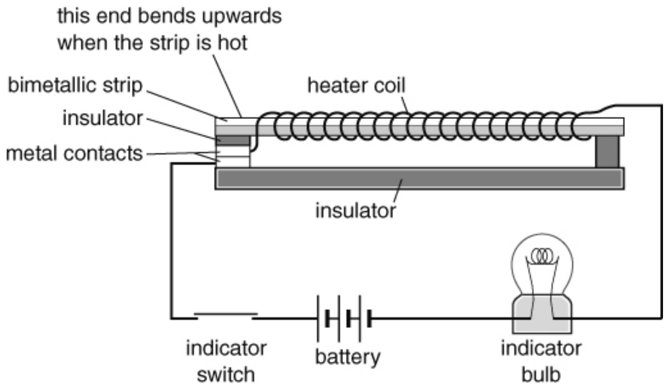
$$\text{length change} = 5\text{ m} \times \frac{30\text{ °C}}{10} \times 1.9\text{ mm/m/°C}$$
$$= 28.5\text{ mm}$$

1 How much will a 10 m long piece of steel expand if you heat it by 10 °C?

2 How much will a 20 m long piece of iron contract if you cool it by 15 °C?

3 Tower Bridge in London has a steel walkway between the two towers which is 33.5 metres long. You can see the traffic below through some of the expansion gaps. If the bridge cools from 30 °C to 10 °C, what is the total increase in the width of all the expansion gaps?

The diagram shows a device that can be used to work the blinking turn indicator lights on a car. The bimetallic strip consists of two different metals stuck together. It bends upwards when it gets warm.



4 Suggest how the unit works. Your answer should include how the strip is heated, what happens to the circuit when it bends, and what happens when it cools down again.

5 The bottom part of the bimetallic strip is made from copper and the top from iron.

a Explain why the strip bends when it is heated.

a A second strip is made from brass on the bottom and steel on the top. How would the bending of this strip compare to the copper and iron one? Explain your answer.

b Suggest *two* metals that could be used to make a strip that bends in the opposite direction.

I can…
- calculate the expansion of different materials
- explain a practical use of expansion.

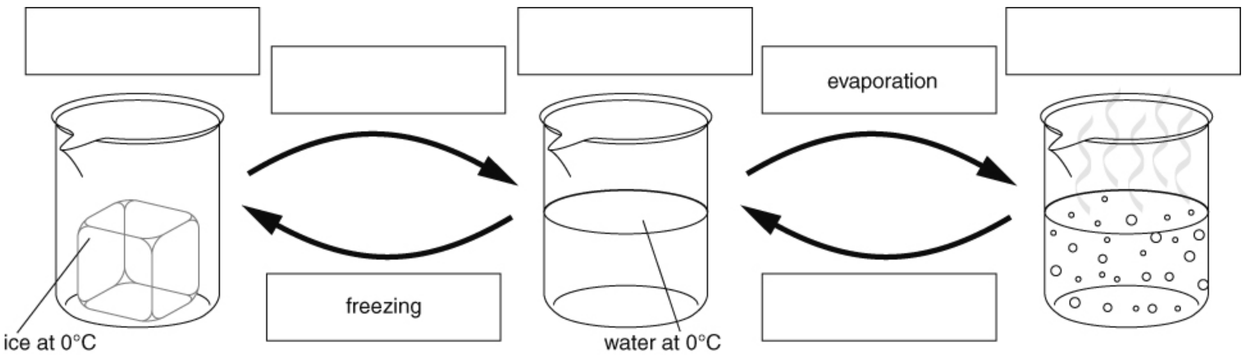
Name ________________ Class ________ Date ________

1 Tick (✓) the boxes to show if each of these things is a physical or a chemical change.

	Physical change	Chemical change
a an acid neutralising an alkali	☐	☐
b butter melting	☐	☐
c salt dissolving in water	☐	☐
d a puddle evaporating	☐	☐
e natural gas burning	☐	☐

2 Use the words in the box to label the diagrams.

condensing	gas	liquid	melting	solid



3 Complete the sentences by crossing out the words that are wrong.

a No new substances are made in a (chemical/physical) change. All the original substances are still present, but they may be in a different state.

b Water can (evaporate/boil) from the surface of a liquid at any temperature. The (melting/boiling) point of water is the temperature at which (evaporation/condensation) can also happen inside the liquid.

c The bubbles you see in boiling water are full of (air/water vapour). The cloud you can see above a boiling kettle is made of (drops of liquid water/water vapour).

d Most substances become (more/less) dense when they change from a liquid to a solid. Ice is different, because ice is (more/less) dense than liquid water.

I can…

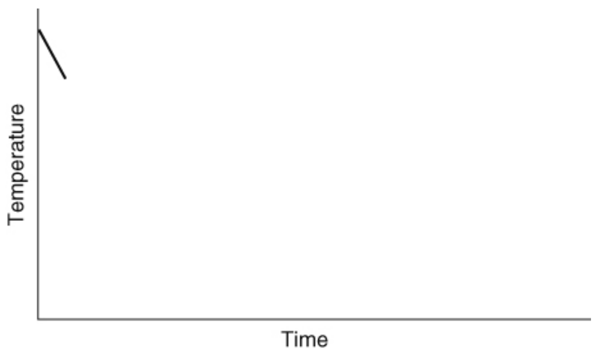
- recall the words that describe changes of state
- identify changes as chemical or physical changes
- recall why ice is different from most other solids.

Your teacher may watch to see if you can:
- follow instructions to carry out a safe investigation.

Aim: To measure the temperature of a liquid as it cools down and turns into a solid.

Prediction

1 Copy this graph into your book. Continue the line on the graph to show what you predict will happen to the temperature.



Apparatus

- tube of hot, waxy liquid in a beaker of hot water (70 °C max)
- thermometer
- stopclock
- test tube rack
- eye protection
- test tube holder

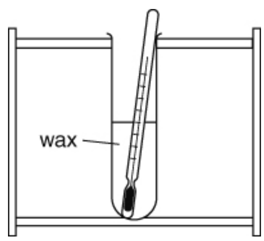
⚠ Wear eye protection.

Take care! The wax will be hot. Use a test tube holder to move the wax from the hot water into the rack.

Do not try to remove the thermometer from solid wax.

Mop up any spills straightaway.

Method



A Copy this diagram into your book and label it using words from the apparatus list.

B Copy the table below into your book. The time must go up to 20 minutes.

C Wear eye protection. Measure the temperature of the hot wax while it is still in the hot water. Write it down in the table.

D Using a test tube holder, take the tube out of the water and stand it in the test tube rack. Start timing.

E After one minute, measure the temperature of the wax. Do not stop the clock. Write the temperature in the table. Look carefully at the wax and decide if it is a solid, a liquid or a mixture of the two and write the observation in your table.

F Take the temperature of the wax each minute and write it in the table. Write down its state each time.

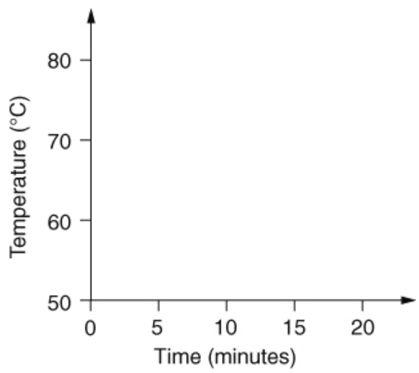
G Keep making your observations until all the wax has turned into a solid.

Recording your results

2 Record your results in a table like this.

Time (minutes)	Temperature (°C)	State of wax (solid, liquid or mixture)
0 (start)		
1		
2		

3 Draw a line graph to show your results. You will need axes like the ones below. Remember to give your graph a title.



Considering your results/conclusions

4 **a** Was the shape of the graph the same as you predicted?

b If not, how was it different?

5 What happened to the temperature of the wax while it was a liquid?

6 What happened to the temperature when the wax was changing from a liquid into a solid?

7 What happened to the temperature when the wax was all solid?

8 What was the freezing point of the wax?

9 Sketch a graph to show what you think would happen to the temperature if you heated the wax up again until it had all melted.

I can…

- follow instructions to carry out a safe investigation
- present data as a line graph
- make predictions using scientific knowledge.

Your teacher may watch to see if you can:

- plan and carry out a safe investigation.

Aim: To measure the temperature of a liquid as it cools down and turns into a solid.

Method

Apparatus

- tube of hot, waxy liquid, beaker of hot water (70 °C max)
- thermometer
- stopclock
- test tube rack
- eye protection
- test tube holder

⚠ Wear eye protection.

Take care! The wax will be hot. Use a test tube holder to move the wax from the hot water into the rack.

Do not try to remove the thermometer from solid wax.

Mop up any spills straightaway.

Prediction

1 What do you think will happen to the temperature of the liquid as it cools down?

2 Sketch a graph of temperature against time to show what you expect to happen.

3 Will the temperature carry on falling when the liquid is changing into a solid? Give a reason for your answer if you can.

4 Explain what will happen to the particles of the wax when the liquid freezes.

Planning

5 Write a method for your experiment. You will need to say how often you will measure the temperature so that you get enough results, and how you will make your investigation safe.

6 Design a results table to show the time, the temperature and the state of the wax. Don’t forget that you will need to take a reading at the start of the experiment (at time zero).

7 Show your plan to your teacher, then carry out your experiment.

Recording your results

8 Fill in your results table neatly.

9 **a** Draw a graph of temperature against time. Draw a smooth line through your points. Remember to give your graph a title.

b Why is it a good idea to display the results in the form of a graph?

Considering your results/conclusions

10 Does the graph look like your prediction? If not, describe how it is different.

11 Explain what happens to the temperature of the liquid as it turns back into a solid.

12 What is the freezing point of the wax?

13 Sketch a graph to show what you think would happen to the temperature if you heated the wax up again until it had all melted.

Evaluation

14 Is there any way you could make your results more accurate?

I can…

- make predictions
- evaluate my method.

Weathering rocks

Rocks get broken up and worn away. This is called weathering. Weathering can happen by chemical or physical changes.

The cards below describe two different ways in which rocks can be physically weathered. Cut out the cards and arrange them into two sequences to explain how these types of weathering happen. There are the same number of cards for each type of weathering. Put the correct diagrams with each sequence.

I can…

- explain how expansion and contraction can break up rocks.

A Eventually layers break off the surface of the rock.

B The outer layers try to expand, and this causes cracks parallel to the surface of the rock.

C When the ice melts, more water can flow into the crack.

D Rocks are not good conductors, so the outer layers of the rock warm up more than the inside.

E The outer layers cool down at night, and may become colder than the inside of the rock.

F The crack may become bigger or longer.

G The water expands when it freezes, and pushes the sides of the crack apart.

H Liquid water runs into a crack in a rock.

I Rocks heat up during the day.

J The outer layers may crack as they try to contract.

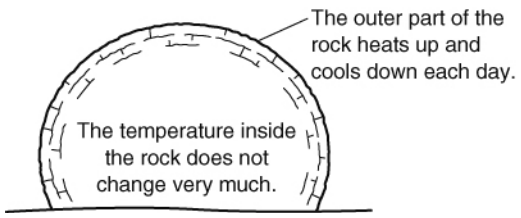
K Freeze-thaw weathering happens when water freezes and melts again.

L The same process happens next time the temperature drops below freezing point.

M Onion-skin weathering happens where there are large temperature changes between day and night.

N After lots of freeze-thaw cycles, the crack may become big enough to completely break up the rock.

1



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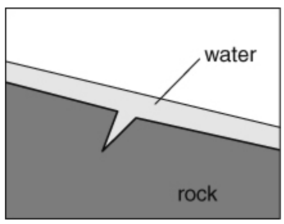

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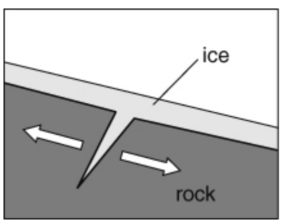

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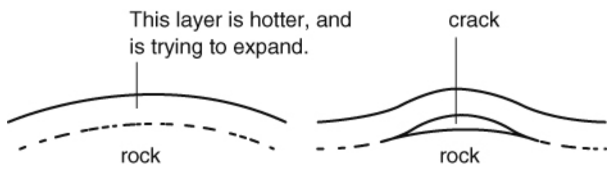
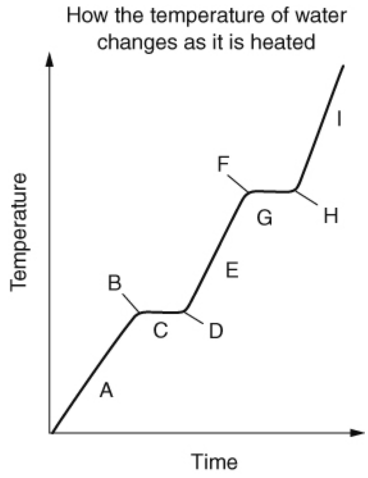


Name ______________ Class ______ Date ______

Ice changes to water and then to water vapour as it is heated. The graph shows how the temperature changes.



1 Is a change of state a physical or a chemical change?

____

2 Write down the letter on the graph that shows when:

a the substance is all liquid ______________

b the substance is all a gas ______________

c the substance is boiling ______________

d the ice is just beginning to melt ______________

e the temperature is 100 °C ______________

f the last drop of liquid has just evaporated ______________

3 Read the statements in the box.

A As a liquid cools down it expands and becomes less dense. The solid it forms is less dense than the liquid.

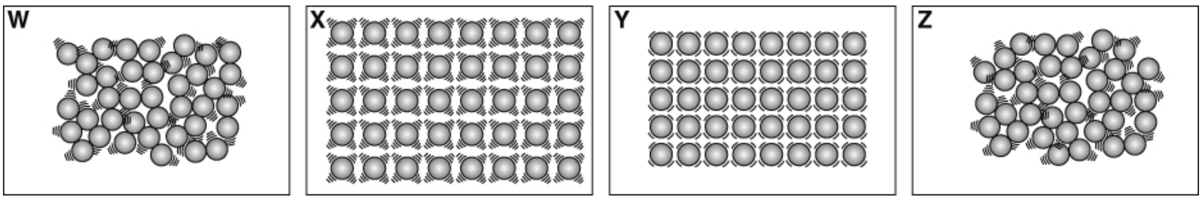
B As a liquid cools down it contracts and becomes more dense. The solid it forms is denser than the liquid.

C As a liquid cools down it contracts, and then starts to expand a little just before it starts to freeze. The solid is less dense than the liquid.

a Which statement describes how water behaves as it is cooled down? ______________

b Which statement describes how most other liquids behave as they cool down? ______________

4 The diagrams show the particles in a substance at different temperatures.



a Which diagrams show a liquid? ______________

b Which diagram of a solid shows the solid at the highest temperature? ______________

c Explain your answer to part b. ______________

____

d Which diagram of a solid shows a substance with the highest density? ______________

I can…

- describe what happens to substances as they change state and change temperature
- use the particle model to explain changes of state and density.

Kitchen questions

One way of cooking potatoes is to put them into boiling water. You can see when the water in a pan has reached its boiling point because lots of bubbles appear in the water.

1 Sam says that the bubbles you see in boiling water are full of air. Explain why he is wrong.

2 Sketch a graph to show how the temperature of the water in a pan changes as it is heated to boiling point. Put time on the horizontal axis and temperature on the vertical axis.

Here are some opinions about the best way to boil potatoes. The amount of energy transferred to the potatoes in the pan depends on the temperature of the water (energy is transferred faster when the water is hotter).

Paul: 'The potatoes will cook more quickly if you keep the heat on full all the time.'

Lucy: 'When the water starts to boil, turn the heat down so there are only a few bubbles in the water.'

Paul and Lucy test their ideas, and find that they both need the same amount of time to cook their potatoes.

3 Explain why both methods take the same time.

4 What is one disadvantage of Paul's method?

Chips are made by cooking pieces of potato in melted animal fat or in cooking oil. These substances have higher boiling points than water. However the chemicals in the fats and oils start to break up before the temperature of the fat or oil reaches the boiling point. This happens at the 'smoke point' of each substance. The smoke point of cooking oil can be from just over 100°C to over 230°C, depending on the type of oil.

5 Suggest why:

- **a** you can cook potatoes faster in cooking oil than in water
- **b** you can burn potatoes if you leave them in hot cooking fat too long, but not if you leave them in boiling water too long.

Water with other substances dissolved in it has a lower freezing point than pure water. When drinks freeze, the water in them turns to ice.

Gavin puts some bottles of drink in the freezer to cool them down quickly, but he forgets about them until the next day.

Approximate temperatures

Freezing point of lemonade: –1 °C

Freezing point of wine: –6 °C

Freezing point of vodka: –27 °C

Temperature inside freezer: –18 °C

6 Explain why:

- **a** the plastic lemonade bottle splits
- **b** the cork gets pushed out of the glass wine bottle
- **c** the vodka bottle still has liquid inside it.

I can…

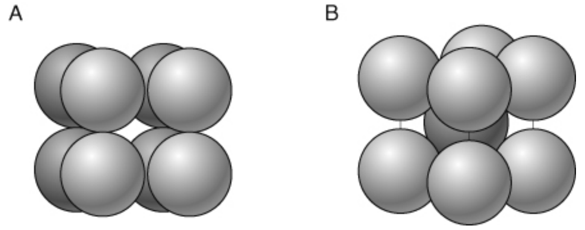
- recall what happens to temperature while a substance is changing state
- explain some consequences of changing the temperature of a substance.

Explaining ice

All matter is made of particles. These particles are of different shapes and sizes.

We think of single atoms as spheres. Elements such as iron have larger atoms than elements like magnesium. Iron atoms also have more mass than magnesium atoms.

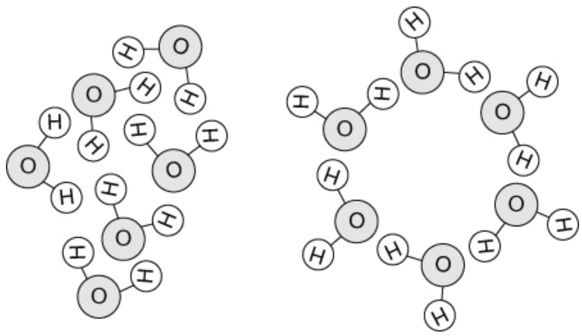
Atoms can be packed together in different ways. The diagrams show just two of the different ways in which atoms can be packed together in a solid. In arrangement B, there are more atoms in each cm^3 of volume.



Two ways in which atoms in a metal can be arranged.

When a substance melts, the atoms move around and take up more space, so the density of the liquid is less than the density of the solid.

Molecules consist of two or more atoms bonded together. Some molecules can be very large, with complicated shapes.



Molecules in liquid water and in ice.

Water molecules consist of an oxygen atom joined to two hydrogen atoms. The three atoms in each molecule are bonded together by very strong forces. There are also weak forces between the hydrogen atoms and oxygen atoms in other water molecules. When the water is liquid, these weak forces are not strong enough to hold the molecules together. However when water freezes they hold the molecules together in a hexagonal arrangement.

1 Give *two* reasons why one metal might be more dense than another.

The table shows some information about different metals. The mass of each atom can be compared to the mass of a hydrogen atom (which is given a mass of 1).

Metal	Mass of atoms	Density (kg/m^3)
magnesium	24	1738
aluminium	27	2800
copper	63.5	8940
zinc	65	7135

2 Look at the information for copper and zinc.

a Why might you expect zinc to be more dense than copper?

b What do their densities tell you about the way atoms are packed in these two metals?

3 Look at the information for magnesium and aluminium. Suggest what this tells you about the arrangement of atoms in these two metals.

4 Suggest why the weak bonds between molecules in water can hold the molecules in a fixed arrangement in ice but not in liquid water.

5 Look at the two diagrams of water molecules. Explain why ice is less dense than liquid water.

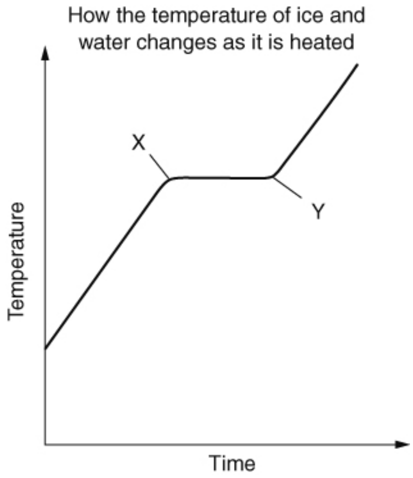
6 As liquid water cools down it becomes more and more dense until it reaches 4 °C. As it cools further it becomes a little less dense. Suggest why this is so.

I can…

- link the density of materials to the mass of the atoms and how closely they pack together
- explain why ice is less dense than water.

Latent heats

The graph shows the temperature change in a beaker of ice as it is heated. Energy is still being transferred to the water after the point marked X.



1 What is happening to the energy being transferred to the ice after point X?

2 Explain why the temperature starts to rise again at point Y.

The energy transferred to melt a solid is called the latent heat of fusion. The energy transferred to turn a liquid into a gas is called the latent heat of vaporisation. 'Latent' means hidden – the energy is 'hidden' because it does not result in a temperature change.

The table shows some numerical values for latent heats, in terms of the energy needed to change the state of 1 kg of a substance.

Substance	Melting point (°C)	Latent heat of fusion (kJ/kg)	Boiling point (°C)	Latent heat of vaporisation (kJ/kg)
water	0	335	100	2272
alcohol	–144	108	78	855

A scald from a hot gas can cause more injury than one from a hot liquid at the same temperature. Your hand will hurt if you spill boiling water on it, as energy from the hot water is transferred to your skin. However the pain and damage to your skin can be even worse if your hand encounters steam at 100 °C. Your hand is cooler than the boiling point of water, so the steam will condense on it and release the extra energy the particles store when they are a gas. This energy is transferred to your skin.

3 Sketch a graph to show what happens to the temperature of a container of water vapour put into a freezer. Explain the shape of the graph in terms of energy transfers and latent heat.

4 A pool of alcohol will evaporate faster than a pool of water at the same temperature. Use information from the table to suggest *two* reasons for this.

5 Which will cause more damage to skin – putting a hand into steam at 100 °C or into alcohol vapour at 100 °C? Explain your answer.

6 **a** Suggest why the latent heats in the table are given in units of energy per kilogram.

b How much energy would it take to melt 2 kg of ice if the ice was at 0 °C?

c How much energy would it take to evaporate 0.5 kg of water if the water is at 100 °C?

7 If you boil food to cook it, it is recommended that you turn the heat from the cooker down as soon as the water in the pan starts to boil. Explain why:

a this does not affect the time it takes to cook the food

b it costs you less in energy bills.

I can…

- use the particle model to explain changes of state and energy transfers.

Name ______________________________ **Class** ____________ **Date** _____________

Tick (✓) the correct boxes to complete the sentences.

1 Fluids are:

- ☐ only liquids
- ☐ only gases
- ☐ only solids
- ☐ liquids or gases.

2 Pressure in a fluid is caused by:

- ☐ the forces from particles hitting the container
- ☐ a heavy object
- ☐ having a small area.

3 Car tyres have high pressure inside them because:

- ☐ they have more air particles inside them
- ☐ they have fewer air particles inside them
- ☐ they are made from rubber

4 Air pressure:

- ☐ is greatest on your head
- ☐ is the same in all directions
- ☐ only pushes on you from the side

5 Air pressure:

- ☐ gets less as you go higher
- ☐ gets less as you go deeper
- ☐ gets bigger as you go higher.

6 Atmospheric pressure is about:

- ☐ 1 Pa
- ☐ 10 Pa
- ☐ 100 Pa
- ☐ 100 000 Pa

7 If a fluid is heated, its temperature

- ☐ increases
- ☐ decreases
- ☐ stays the same

8 Pressure in water:

- ☐ gets less as you go higher
- ☐ gets less as you go deeper
- ☐ gets bigger as you go deeper

I can…

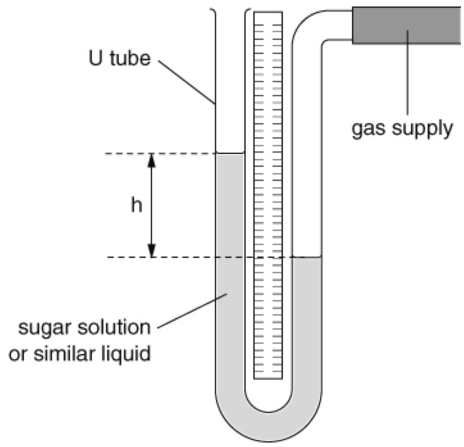
- use the particle model to describe how pressure is caused in fluids
- explain some effects of pressure in fluids
- describe how pressure changes with depth or height.

Your teacher may watch to see if you can:
- carry out a fair and safe investigation.

Aim: to find out the best liquid to use in a manometer.

A manometer is a U-tube filled with a liquid. It can be used to measure gas pressures. The greater the height difference (h) between the liquid in the two arms of the tube, the higher the gas pressure.

Your task is to find the best liquid to use in a manometer.



Method

Apparatus
- glass tubes
- rubber or plastic flexible tubing
- clamps and stands
- ruler
- different salt solutions

⚠ Make sure the gas supply is turned off before you disconnect your manometer.

The laboratory must be well ventilated.

Mop up any spills straight away.

A Set up a manometer as shown in the diagram. Fill it with solution A.

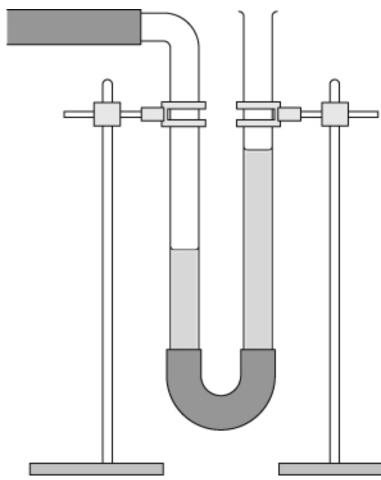
B Connect your manometer to a gas tap and turn on the gas.

C Use your ruler to measure the difference in the height of the liquid in the two arms of your manometer. Write your results in a table.

D Turn off the gas and disconnect the manometer from the gas tap.

E Repeat steps A to D twice more.

F Repeat steps A to E for the other liquids.



Recording your results

1 Make a table like this for recording your results.

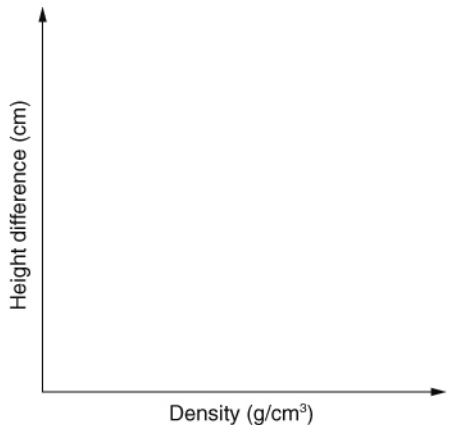
Liquid in manometer	Density of liquid (g/cm^3)	Height difference when connected to gas tap (cm)

2 Work out the average reading for each liquid. Ignore any results that are very different to the other results for that liquid.

3 a Which liquid gave the biggest height difference when you measured the gas pressure?

b Which liquid is the best one to use for a manometer? Explain your answer.

4 Plot a graph to show your results. Use axes like these. Remember to include a title.



5 a Describe the pattern shown in your graph.

b How can you use the densities of liquids to work out which is best for a manometer.

6 a How accurate are your results? (How carefully did you take the measurements?)

b Is there any way you could have made your measurements more accurate?

7 a How sure are you of your results?

b Explain your answer to part a.

c What could you do that would allow you to be more sure of your results?

8 Have you got enough evidence to be sure of your conclusion?

I can…

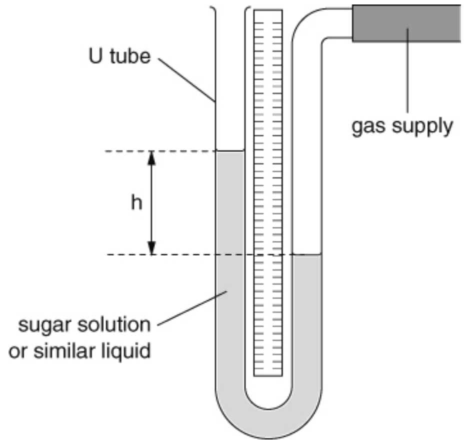
- make careful observations
- draw a graph to show my results
- draw a conclusion
- evaluate the accuracy and reliability of my evidence.

Your teacher may watch to see if you can:
- plan and carry out a fair and safe investigation.

Aim: to find out the best liquid to use in a manometer.

A manometer is a U-tube filled with a liquid. It can be used to measure gas pressures. The greater the height difference (h) between the liquid in the two arms of the tube, the higher the gas pressure.

Your task is to find the best liquid to use in a manometer.



Method

Apparatus
- glass tubes
- rubber or plastic flexible tubing
- clamps and stands
- ruler
- denatured alcohol
- salt
- beakers or test tubes
- measuring cylinder
- balance

⚠ Make sure the gas supply is turned off before you disconnect your manometer.

The laboratory must be well ventilated.

Denatured alcohol is flammable.

Mop up any spills straight away.

Preliminary work

A Make a manometer using the glass and rubber tubing and some water. Use your manometer to measure the height difference produced by the pressure of the laboratory gas supply.

B Repeat step A using denatured alcohol in your manometer instead of water.

C Use the measuring cylinder and balance to help you to work out the densities of the two liquids.

Planning

1 Plan an investigation to find out the best liquid to use in a manometer. You could think about these things:
- Does the density of the liquid make any difference?
- How could you make up liquids of different densities to test?
- What range of densities will you test and how many different densities?
- Do you need to repeat any measurements?

2 Write down what you will do and how you will make sure your investigation is safe and fair.

3 Show your plan to your teacher before you start.

Recording your results

4 How will you present your results? Explain why you chose these method(s).

Considering your results/conclusions

5 Do your results show a relationship between the density of the liquid in the manometer and the height difference when it is measuring gas pressure?

6 Which is the best liquid from the ones you measured to use in a manometer? Explain which criteria you used to decide which liquid is best.

Evaluating your results

7 **a** Accurate measurements are measurements that are close to the true value. How accurate were your measurements?

b How repeatable were your results? (Did you get the same value if you repeated a measurement?)

c Results are reproducible if other teams get the same results. How reproducible were your results?

8 Were there any variables you could not control?

9 Are your results reliable enough for you to be sure of your conclusion?

I can…

- make careful observations
- record results and draw a conclusion
- evaluate the accuracy and reliability of my results.

Writing voice-overs

A preposition is a small word that shows the relationship between other things. The box on the right shows some examples of prepositions. They are often used in prepositional phrases (a preposition with a noun or noun phrase) to indicate place or time. Prepositional phrases are often used at the beginning of sentences, but they can also be used in the middle or at the end of sentences.

They can be useful in science for being clear about where or when something happened.

above	around
as soon as	at the start
beneath	in
in the end	on
under	within

1 Write the voice-over for a short documentary on one of these topics:

- using expansion and contraction
- altitude sickness.

Use the facts you have already researched, and make sure that you present them clearly. Try to use prepositional phrases to help you to do this. The boxes below provide some phrases that you could use.

Using expansion and contraction

After the engineers put up the telephone wires …

In cold weather …

… at the ends of the bridge.

As the hot water runs over the lid …

After the metal rod is heated …

Inside the thermometer …

After the two strips of metal have warmed up …

Inside the metal, the particles …

Altitude sickness

High in the mountains …

At higher altitudes …

Inside the Gamow bag …

Inside the lungs …

As soon as the climber …

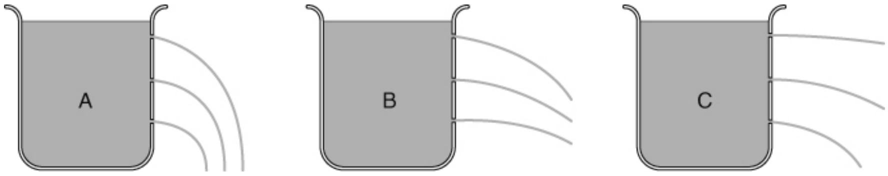
I can…

- use prepositional phrases in writing to be clear about where and when things happen.

A question of pressures

Name ______________________ **Class** __________ **Date** __________

1 These diagrams show water coming out of a can with holes in its sides. Only one of these diagrams is correct.

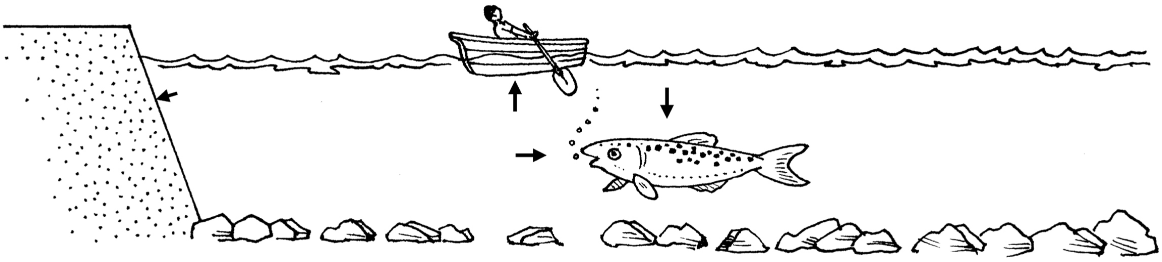


a Which diagram is correct? ______________________

b Explain why you chose this answer. ______________________

____

2 The diagram shows part of a reservoir. Add arrows to the diagram to show the water pressure on the dam, the boat and the fish. Use longer arrows to represent higher pressures, and remember that pressure increases with depth. A few arrows have been drawn for you.



3 Air pressure at sea level is about 100 kPa. Why are we not crushed by this pressure?

____

____

4 This table shows how air pressure decreases with height above the Earth.

Height (m)	Air pressure (kPa)
0	100
2000	75
5000	50
10 000	25
15 000	10

Plot a graph on graph paper to show this information. Put air pressure on the horizontal axis and height on the vertical axis. Your scale for the height axis can go up in 2000s, from 0 to 16 000 metres. Don't forget to give your graph a title.

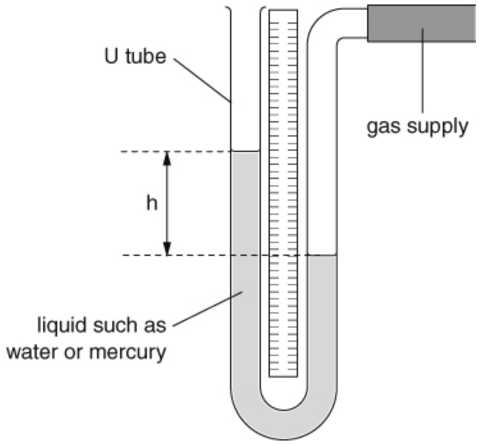
5 Use your graph to find the air pressure at 3000 m. ______________________

I can…

- recall that water pressure increases with depth
- recall that air pressure decreases with height
- plot a graph using a smooth curve.

Manometers

A manometer is an instrument used to measure gas pressures. It consists of a tube containing a liquid and one end is connected to the gas supply to be measured. The difference in the height of the liquid in the two arms is a measure of the gas pressure.



The weight of a liquid in a tube is given by:

$$F = \rho \times g \times A \times h$$

Where:

F = weight (in N)

ρ = density of the liquid (in kg/m^3) (ρ)

g = force of gravity on each kilogram of mass (= 9.81 N/kg)

A = cross-sectional area of the tube (in m^2)

h = height difference of the liquid in the two arms of the tube (in m).

Pressure = $\frac{F}{A}$, so P = $\frac{\rho \times g \times A \times h}{A}$

A ÷ A = 1, so P = ρ × g × h.

You may also need to use this version of the formula.

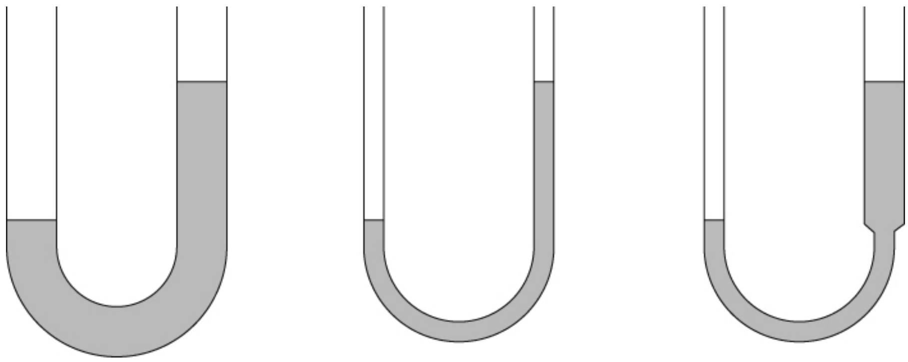
h = $\frac{P}{\rho \times g}$

(You do not need to remember the formulae given here.)

Liquid	Density (kg/m^3)
mercury	13 950
water	1000
ethanol	789

1 A manometer measures the difference between the pressure of the gas supply and atmospheric pressure. Refer to the diagram and explain why this is so.

2 These manometers would all have the same height difference if they were connected to the same supply. Explain why the diameter of the tubes has no effect on the height difference in the liquid. Refer to the equations above in your answer.



3 The difference in water level in a manometer is 0.50 m.

- **a** Use the formula to calculate the pressure this represents.
- **b** Calculate the height difference if the tube were filled with ethanol instead. (*Hint*: use the version of the formula with h on the left.)
- **c** What would be the difference in height if the tube were filled with mercury?

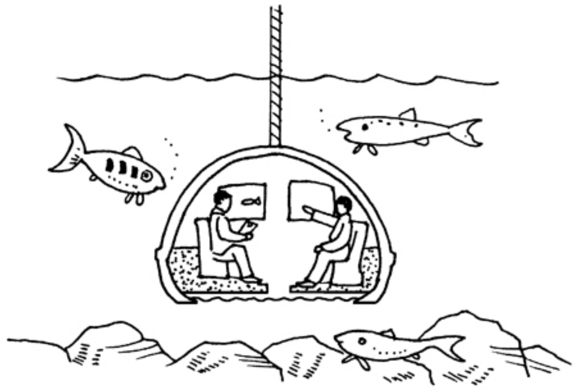
4 Manometers in school laboratories are usually filled with water rather than ethanol or mercury.

- **a** What advantage would mercury have compared to the other two liquids?
- **b** What advantages does water have compared to the other two liquids?

I can…

- explain how a manometer works
- use the formula for calculating the pressure in a liquid.

A diving bell can be used to take people down into the ocean safely. It is made of metal, with an open bottom, and weighted so that it stays the same way up. It is usually hung from a ship and supplied with compressed air.



1 Explain, using ideas about particles, why gases are compressible and liquids are not.

2 **a** What happens to the water pressure as you go deeper?

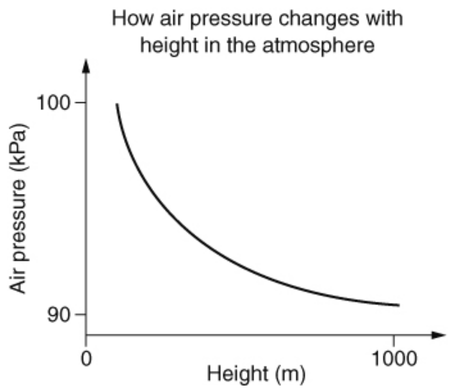
b What effect would this have on the air in the diving bell?

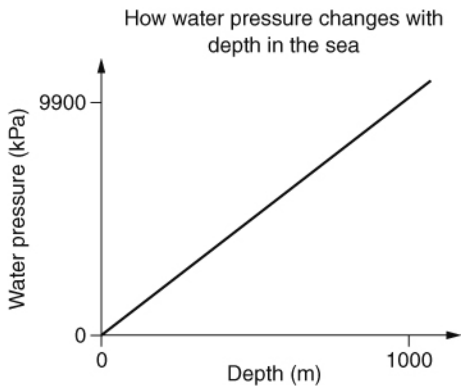
3 Suggest *two* reasons why the diving bell needs to be supplied with compressed air from the surface

The deepest that people have ever been beneath the sea was 10 915 m. The dive was made in 1960 by Jaques Piccard and Donald Walsh in the *Trieste* bathyscaphe. A bathyscaphe is a sealed vessel so the divers do not need to be supplied with compressed air.

4 What are the benefits and drawbacks of a using a bathyscaphe instead of a diving bell?

5 The graphs show how air pressure changes with height in the atmosphere and how water pressure changes with depth in the sea.





a Describe the similarities and differences between the two graphs.

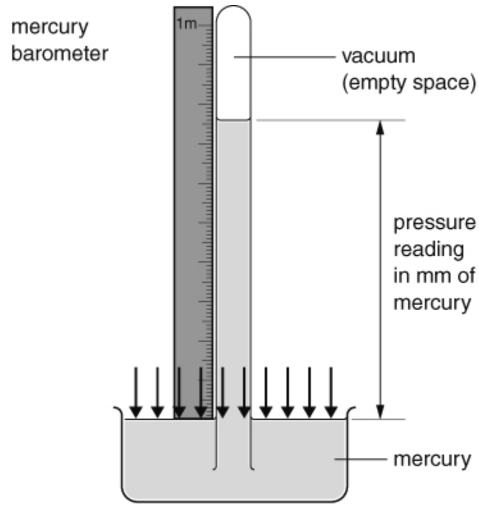
b Gases can be compressed easily and liquids cannot. Use this idea to help you to explain why the graphs are different shapes.

I can…

- explain how a diving bell works
- explain the differences between air pressure and water pressure using the particle model.

Barometers and altimeters

A barometer is an instrument used to measure air pressure. The first barometers were tubes of mercury set in a reservoir full of mercury. The tube was first completely filled with mercury so that all the air was removed. It was then turned upside down and placed in a tank of mercury.



Atmospheric pressure pushes down onto the mercury in the tank and stops the mercury falling out of the tube. There is a column of mercury left in the tube with a vacuum above it. If there is any change in the atmospheric pressure the height of the mercury column in the tube will change. At a pressure of 'one atmosphere' or 100 kPa there is 760 mm of mercury in the tube. An early unit for air pressure was inches of mercury or "Hg. The average atmospheric pressure is about 30 "Hg (or 760 mm Hg).

The pressure of the atmosphere can be worked out in modern units by working out the pressure under the column of mercury.

$$P = \rho \times g \times h$$

Where:

P = is the pressure (in pascals (Pa))

ρ = is the density of the liquid (in kg/m^3) (ρ)

g = is the force of gravity on each kilogram of mass (= 9.81 N/kg)

h = is the height of the mercury column (in m).

Liquid	Density (kg/m^3)	Freezing point (°C)
mercury	13 590	–39
water	1000	0
ethanol	789	–117

The formula can be rearranged:

$$h = \frac{P}{\rho \times g}$$

1 Calculate atmospheric pressure in pascals on a day when a mercury barometer is reading 750 mm.

2 What height of mercury would be in the tube on a day when the air pressure is 95 000 Pa?

3 Give *two* reasons why mercury is a more suitable liquid than water or ethanol for measuring air pressure in the UK. Use calculations to illustrate your answer.

4 Why would a scientific expedition to the Antarctic have difficulty measuring the air pressure using a barometer like the one described above? Give as many reasons as you can.

The barometer above is too large to have on the wall at home or in the office. An aneroid barometer is much smaller than a mercury barometer but is less accurate. Aneroid barometers are easier to read and much less likely to be damaged.

An altimeter is a special type of aneroid barometer used by pilots and mountaineers. It has a scale that gives the height above sea level. This is worked out from the difference between air pressure, where the aeroplane or mountaineer is, and the normal sea level pressure (1 atmosphere).

5 Altimeters have a knob that allows the pilot to adjust the pressure at which the altimeter reads zero. Suggest why this is necessary.

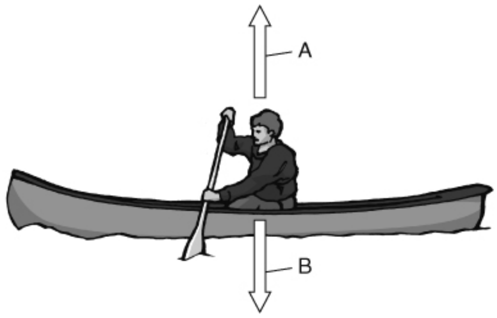
6 Optional extra: Find out how an aneroid barometer works. Draw a labelled diagram to explain how it works.

I can…

- explain how barometers work
- carry out calculations on the pressure in liquids.

Name ______________________________ Class ____________ Date ____________

1 The drawing shows a canoe.



a What is the name of force A? Tick (✓) *one* box.

☐ weight ☐ lift ☐ lightness ☐ floating force ☐ upthrust

b What is the name of force B? Tick (✓) *one* box

☐ sinking force ☐ weight ☐ heaviness ☐ downthrust

2 The density of water is 1 g/cm^3. Which of these materials will float in water? Tick (✓) the correct boxes in the table.

Material	Density (g/cm^3)	Float?	Sink?
wood	0.7		
iron	8		
polystyrene	0.01		
ice	0.92		
aluminium	2.7		

3 Complete these sentences using words from the boxes. You can use each word once, more than once or not at all.

air	density	faster	greater	less	more	slower	water

A hot air balloon flies because the __________ of the balloon (including the basket and the passengers) is __________ than the density of the __________ surrounding it. The air inside a hot air balloon is heated to make the particles move __________ and take up __________ space. This makes the density of the hot air __________.

A steel ship floats because the overall __________ of the ship, including all the air spaces inside it, is less than the density of __________.

I can…

- state what upthrust means
- explain why some objects float
- use the density of a material to predict if it will float in water.

Your teacher may watch to see if you can:

- carry out a safe investigation.

Aim: to find out which factors affect the amount of upthrust on an object.

Introduction: An object suspended in water appears to weigh less than the same object suspended in air. The difference is caused by upthrust from the liquid.

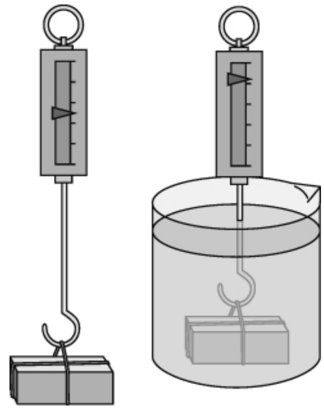
You are going to find out if the density of the object affects the amount of upthrust, and if the volume of the object affects the upthrust.

Method

Apparatus

- different solid materials
- calculator
- string
- ruler
- force meter
- beaker
- balance

⚠ Mop up any spills straight away.



A Select *five* different materials with the same volume. All the materials should sink if you put them in water.

B Use the balance to find the mass of each one and write it in the table.

C Find the volume of each sample, and work out its density.

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

D Use the force meter to find the weight of each sample in air.

E Suspend each sample in water using the force meter. Write down its weight in water.

F Calculate the upthrust.

upthrust = weight in air – weight in water

G Now find three samples of one of the materials from Step A. The three samples should all be different sizes. The samples should all sink if you put them in water.

Repeat steps **B** to **E** for these materials.

Recording your results

1 Make a table like this for your results.

Material	Mass (g)	Volume (cm^3)	Density	Weight in air (N)	Weight in water (N)	Upthrust (N)

2 Draw a scatter graph to show the results for the materials you selected in step A. Put density on the horizontal axis and upthrust on the vertical axis. Don't forget to give your graph a title.

3 Draw a scatter graph to show the result for the samples you selected in step F. Put volume on the horizontal axis.

Considering your results/conclusions

4 How does the upthrust depend on the density of the object or on its volume? Explain how you worked out your answers by referring to your graphs.

I can…

- work out upthrust
- calculate density from measurements of mass and volume
- draw a conclusion.

Upthrust in different liquids

Your teacher may watch to see if you can:
- plan and carry out a fair and safe test.

Aim: To find out whether the amount of upthrust depends on the liquid.

Introduction: You are going to find out if the amount of upthrust depends on the liquid. Even objects that sink have upthrust acting on them, but the upthrust is not big enough to make them float.

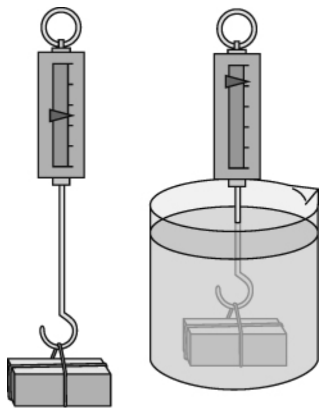
You can measure upthrust by finding out how much the weight of an object changes when you put it into a liquid.

Method

Apparatus
- force meter
- different liquids
- string
- beaker
- object
- balance
- measuring cylinder

⚠ Mop up any spills straight away.

A Write a method for your investigation. Remember to say:
- how you will work out the densities of the different liquids
- what you will measure
- how you will make sure that your investigation is fair.



Recording your results

1 Make a results table like this:

Liquid	Weight in air (N)	Weight in liquid (N)	Upthrust (N)	Density of liquid (g/cm^3)

2 Carry out the experiment and fill in your table. You calculate the number in the fourth column using this formula:

upthrust = weight in air – weight in liquid

Considering your results/conclusions

3 Does the upthrust depend on the kind of liquid?

4 What is the connection between the density of the liquid and the amount of upthrust it provides?

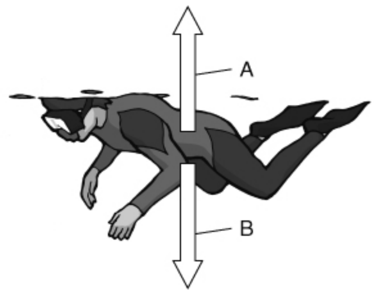
I can…
- record my results
- use my results to calculate the upthrust on an object
- describe the link between upthrust and density of a liquid.

Floating questions

Name ______________________ **Class** __________ **Date** __________

Josh is learning to dive.

1 This is Josh floating in the water. Label the *two* forces.



2 Josh picked up a rock from the sea bed. It was easy to lift. It felt much heavier when he carried it up the beach.

Why did the stone feel lighter when it was under the water?

____

____

____

____

Josh wanted to find out which objects would feel heaviest under water. He weighed some different objects in water and out of water. The table shows his results.

Object	Weight in air (N)	Weight in water (N)	Upthrust (N)
stone	30	18	12
brick	22	11	
wooden block	40	0	
iron weight	50	44	
lead weight	20	18	

3 **a** Which object felt the heaviest when Josh weighed it in air? ______________________

b Which felt the heaviest in water? ______________________

4 The upthrust is the difference between the two weights.

a Calculate the upthrust for each object and write it in the table. The first one has been done for you.

b Which object had the biggest upthrust? ______________________

5 **a** Which object floated in water? ______________________

b How can you tell this object floats from the information in the table? ______________________

____

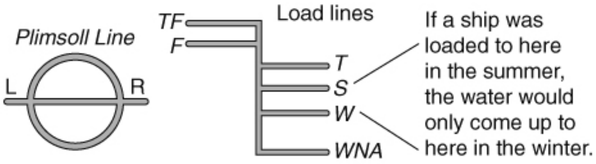
I can…

- explain what upthrust does
- calculate the upthrust on objects
- use data to predict which objects will float in water.

The Plimsoll line

This story started about two hundred years ago in the early days of the British merchant navy. Greedy ship owners would often overload the ships with goods they wanted to sell in far-away countries. Because they were so overloaded, many ships would sink if they met a storm at sea. The sailors' families had to wait for months before they knew if the crew had survived the trip. Many never came back – they were 'missing, presumed lost'.

In 1870, a member of Parliament called Samuel Plimsoll decided that too many ships were being lost at sea due to overloading. He passed a law forcing ship owners to have a special line painted on the side of each ship. Loading of the ship had to stop as soon as the water level reached this line. If the water level went above the line, the ship owners would be fined or imprisoned.



TF	Tropical Fresh Water	*W*	Winter
F	Fresh Water	*WNA*	Winter North Atlantic
T	Tropical Salt Water		
S	Summer		

The 'Plimsoll line' is still in use today and can be seen painted on the side of all cargo ships. Ships also have load lines for different parts of the world. These are very important for ships which travel from the cold seas of Britain to the warmer tropical seas. Warm sea water produces slightly less upthrust than cold sea water, so ships float lower down in warm water. Fresh water also produces less upthrust than sea water.

1 Why did ship owners want to overload their ships?

2 Why was this dangerous?

3 What did Samuel Plimsoll force ship owners to do?

4 Why is it dangerous for a fully loaded ship to travel from the sea into a fresh water river?

The upthrust on a ship depends on the volume of the ship that is below the surface of the water (this is the same as the amount of water displaced, or pushed out of the way by the ship). It also depends on the density of the water. Sea water is denser than fresh water at the same temperature.

5 Explain why warm water produces less upthrust than cold water. Use ideas about particles and density in your answer.

6 There are two reasons why tropical fresh water produces less upthrust than water in winter in the North Atlantic. What are they?

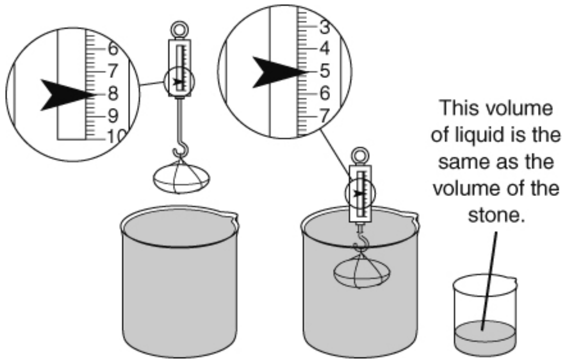
7 An apple is floating in a bowl of water. You add lots of salt to the water in the bowl. How does this affect the way the apple floats?

I can…

- describe how the densities of substances change at different temperatures
- use the particle model to explain density changes at different temperatures
- recall the factors that affect the amount of upthrust on an object.

Archimedes

Archimedes lived in Syracuse, Italy, and was a great inventor and philosopher. One of the scientific facts that he discovered is called Archimedes' principle, 'the upthrust on something in a fluid is equal to the weight of fluid displaced.'



1 If you compare the weight of the stone in air with its weight in water, the difference would be the weight of the water displaced by the stone.

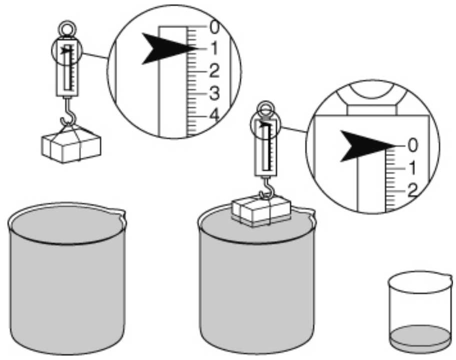
This difference is the upthrust.

a What is the weight of the stone?

b What is the upthrust on the stone when it is in the water?

c What is the weight of the water in the small beaker?

d Why doesn't the stone float?



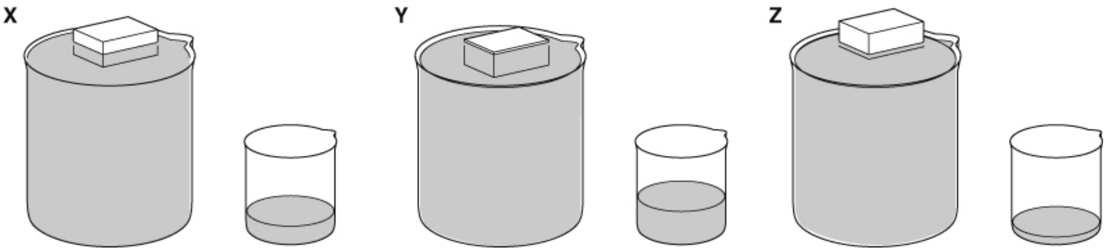
2 **a** What is the weight of the wooden block?

b What is the upthrust on the block?

c What is the weight of the water in the small beaker?

d Why does the wooden block float?

3 All the beakers have water in them. The blocks are all the same size, and the small beakers are holding the water that the blocks have displaced.



a Which object is the heaviest? How do you know?

b Write the three objects in order of their weight, starting with the heaviest. Explain how you worked out your answer.

4 **a** What would happen if you put a 1 N weight on top of block Z?

b What would the extra water in the small beaker weigh?

5 Optional extra:

a Find out what an Archimedes screw is and what it is used for.

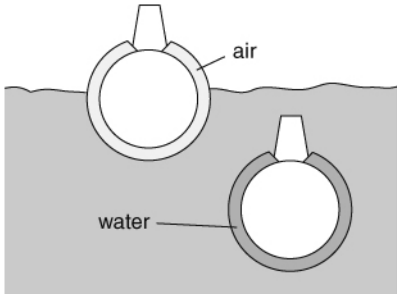
b Find out how Archimedes worked out that the king of Sicily had been cheated by a man making his crown.

I can…

- use ideas about displacement to work out if an object will sink or float.

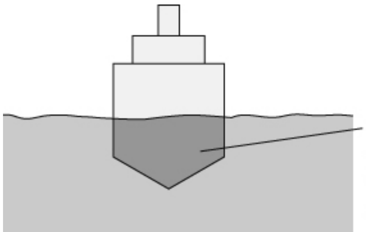
Submarine sums

Most ships are made out of steel and other materials that are more dense than water. They float because the overall density of the ship, including all the air spaces inside, is less than the density of water.



Submarines can sail on the surface of the water, or beneath the surface. The buoyancy of a submarine needs to be adjustable to allow it to do this. Submarines have ballast tanks that are full of air when the submarine is sailing on the surface. These are then partly or completely filled with water to make the submarine sink below the surface.

Information about ships does not normally give the mass of the ship but its displacement. This is the mass of water the ship displaces when it is floating. The mass of water displaced is the same as the mass of the ship. The upthrust is equal to the weight of the fluid displaced.



Fact box

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

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

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

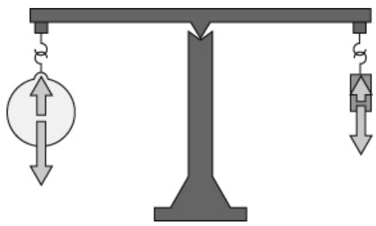
1 A submarine has a displacement of 8000 tonnes (8 000 000 kg) when it is sailing on the surface of the sea.

- **a** What is the mass of the submarine?
- **b** Calculate the volume of water it displaces.

2 The same submarine has a displacement of 9000 tonnes when it is sailing 300 m below the surface.

- **a** Explain why the displacement is larger when the submarine is submerged.
- **b** Suggest what the overall density of the submarine is when it is submerged.
- **c** What can you say about the overall density of the submarine when it is on the surface?
- **d** How has the density been changed?

3 This instrument is called a Dasymeter. It is a balance with a hollow glass sphere on one side and a much smaller, denser block on the other. The downwards force on each object is the difference between its weight and the upthrust on it.



- **a** Why is there upthrust on the sphere and the block?
- **b** When the Dasymeter is used in a submarine where the air pressure is higher than atmospheric pressure, the side with the glass sphere rises. Explain why this happens, using ideas about displacement.
- **c** Explain what will happen if the Dasymeter is used where the air pressure is less than atmospheric pressure.

I can…

- use the formula relating mass, volume and density
- use ideas about density changes to explain how the depth of a submarine is controlled
- use ideas about displacement and upthrust to explain phenomena.

Name ______________________ Class __________ Date __________

1 This cyclist wants to go as fast as possible. Join the boxes to show how different features of the cyclist and her bike help her to go fast.

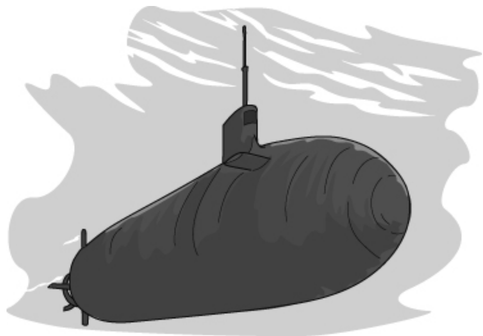
Helmet pointed at the back	larger force to balance the drag forces
Strong leg muscles	smaller area that meets the air in front
Crouched down riding position	makes no difference to speed
Black painted bike	streamlined shape

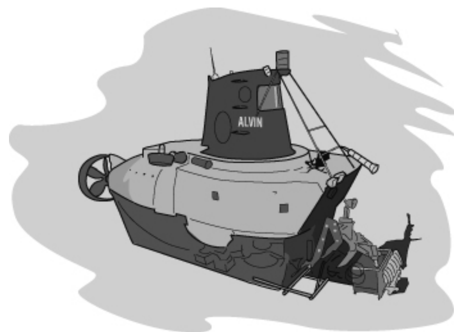
2 Two identical cars are driving along the motorway. Car A is travelling at 50 km/h and Car B is travelling at 80 km/h.

a Which car has the most drag acting on it? ______

b Which car needs the biggest force from its engine to keep moving at a steady speed? ______

3 Look at the drawings of a US Navy submarine, and the submersible *Alvin*.





a Which one is the biggest? ______________________

b Which one has the most streamlined shape? ______________________

c Which one is the fastest? ______________________

d The speed of a vehicle has a big effect on the drag. Which vehicle do you think has the smallest drag? Explain your answer. ______________________

____

____

I can…

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

Streamlined shapes 1

Your teacher may watch to see if you can:
- make careful observations.

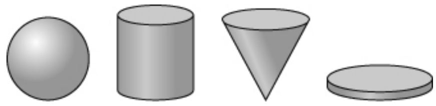
Aim: to find out which shapes are the most streamlined.

Method

Apparatus
- non-fungicidal wallpaper paste
- stopclock
- modelling material
- large beaker
- measuring cylinder
- eye protection

⚠ Don't touch your eyes or mouth during the experiment.
Wash your hands afterwards.

A Divide your Plasticine® into six equal pieces. Make four of the pieces into the shapes shown here.



B Invent your own shapes for the other two pieces.

C Make a results table like the one below. Draw the shapes in the first column.

D Fill the measuring cylinder with wallpaper paste to near the top.

E Drop each shape into the wallpaper paste and time how long it takes them to fall to the bottom. Record your results in the table.

F Empty the wallpaper paste into the large beaker. Carefully take out your shapes and pour the wallpaper paste back into the measuring cylinder. Put more paste in to fill the measuring cylinder up to the same level.

G Repeat steps D to F until you have three sets of readings for each shape. Calculate the mean time by adding up the three times for each shape and then dividing by three.

Recording your results

Shape	Time to fall (s)			Mean time to fall (s)
	1st fall	2nd fall	3rd fall	

Considering your results/conclusions

1 Which shape reached the bottom of the measuring cylinder the quickest?

2 Which shape had the best streamlining?

Evaluation

3 Why did you need to take three sets of readings?

4 Was your test a fair test? Explain your answer.

5 How could you improve your experiment if you had time to do it again?

I can…
- work out mean values from my results
- draw a conclusion
- describe the reliability of my data.

Your teacher may watch to see if you can:

- plan and carry out a fair test.

Aim: to find out which is the best shape for streamlining.

Introduction: You can drop different shapes into wallpaper paste to find out the best shape for a streamlined object.

Apparatus

- non-fungicidal wallpaper paste
- measuring cylinder
- large beaker
- modelling material
- metre rule
- balance
- stopclock

⚠ Don't touch your eyes or mouth during the experiment.

Wash your hands afterwards.

Planning and predicting

1 Which shapes will you test? Explain why you want to test these shapes.

2 Predict which shape will have the best streamlining, and explain why you think so.

3 How will you decide which shape has the best streamlining?

4 Write a method to describe how you will carry out your investigation. You need to explain:

- how you will make sure that your investigation is a fair test
- how you will keep yourself and others safe while you are doing the experiment
- what you will measure, how you will measure it and how you will record it
- whether you will need to make any preliminary measurements
- how you will make sure your results are reliable
- how you will make sure that your test is safe.

5 Show your plan to your teacher before you start.

Recording your results

6 Design a table to record the results of your experiment.

Considering your results/conclusions

7 Which shape had the best streamlining? Was your prediction correct?

8 Try to explain your results using ideas about particles.

Evaluation

9 Are your results repeatable? Are they reproducible? Explain your answer.

10 How could you improve your experiment if you had time to do it again? Explain why you would make each improvement.

11 Are there any further investigations you could carry out to find out more about streamlining?

I can…

- make a prediction
- make careful observations
- draw a conclusion
- evaluate the reliability of my results.

Diving experiments

Diving suits were invented in the 1800s and allowed men to work underwater to salvage wrecked ships or do other work. However when divers came back to the surface they would often suffer terrible pains in their muscles or joints. Some divers were permanently damaged and some even died. This was called decompression sickness. Divers avoided this problem by descending slowly and then stopping several times on their way to the surface after they had finished their dive.

In 1906, the Royal Navy asked Professor J. S. Haldane (1860–1936) to find out how fast divers could come to the surface without getting decompression sickness. Haldane and his team first experimented using goats, as their breathing system is similar to humans. The goats were put into a large steel chamber and the air pressure was increased. The air pressure was reduced again at different rates to see what effect the rate of change of air pressure had on the goats. Most of the goats suffered decompression sickness during the tests and some of them died.

Once Haldane and his team had come up with a set of guidelines for divers that they thought should work they used the chamber to test the guidelines using themselves as test subjects and then finally repeated the tests during real dives in the sea. In 1908, the team sent the Royal Navy a set of decompression tables that divers could look up to work out how long to stop for and at what depths as they came to the surface.

The British Ministry of Defence continued to use goats in experiments until 2008, investigating the safety of submarine crews who had to abandon their submarines. In 2008, they decided that they had enough information from the experiments and could conduct any further research needed by computer modelling.

Today there are internationally accepted criteria that are used to decide whether research on humans should be allowed. These criteria include:

- having informed consent
- the tests should have first been carried out on animals
- the tests should not cause permanent damage
- the benefits that might be gained should outweigh the possible risks.

1 Suggest why Haldane's team:

a started by experimenting on goats

b experimented on themselves.

1 a Do you think that animals should have been used in the experiments? Explain your answer.

b Do you think that Haldane and his team should have experimented on themselves? Explain your answer.

2 A spokesperson for animal rights says: 'None of these tests should have been carried out on animals – they should have used computer models from the start!'

a Why didn't Haldane use computer models?

b Which do you think is the best way to investigate medical questions – computer models or using animals as models?

3 a Which of the guidelines for human experiments cannot be applied to animals?

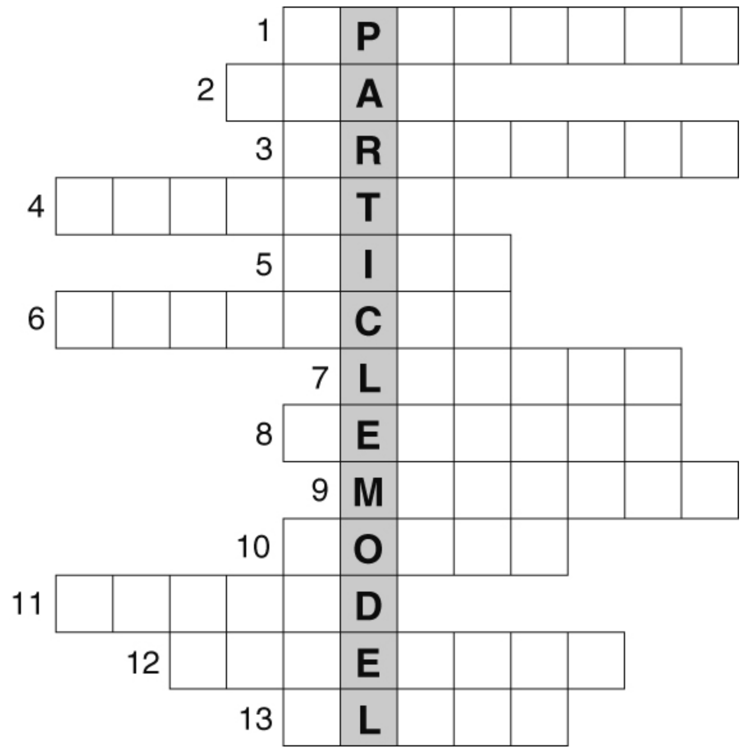
b Do you think the other criteria should be applied when deciding if animal experiments should go ahead? Explain your answer.

I can…

- discuss why animals and humans are used in experiments
- express my own views in a piece of writing.

Name ________________________________ **Class** _____________ **Date** ______________

Fill in the missing letters on the grid by answering the clues.



Clues

1 The force that balances your weight when you float.

2 A name that describes air resistance and water resistance.

3 The units for this are pascals.

4 A word that describes how particles move in a solid.

5 An object will do this if its density is greater than the density of water.

6 Melting is this type of change.

7 The state of matter when particles can move around but are still close to each other.

8 You can calculate this from a mass and a volume.

9 When the particles in a solid break away from their fixed positions and start to move around.

10 The state of matter when particles have the least energy.

11 What happens to materials when they are heated.

12 The _________ point is the same temperature as the melting point.

13 A word that describes liquids and gases.

I can…

- recall key words connected with states of matter
- recall key words connected with fluids and forces.

Fuel consumption

The table shows the fuel consumption of two different lorries when they are travelling at different speeds.

Speed (mph)	Miles travelled per litre	
	Lorry A	Lorry B
50	1.43	1.55
55	1.33	1.45
60	1.21	1.33
65	1.08	1.20
70	0.82	0.95

1 **a** Plot a scatter graph to show the information in the table and draw a line of best fit through each set of points. Put speed on the horizontal axis. Add a key to show which line refers to which lorry, and give your graph a title.

b Explain why presenting results as a graph is useful.

2 Engines use energy stored in the fuel to produce a force. Why do the lorries need a force to keep them moving at a steady speed?

3 **a** How can you tell from the information in the table that the lorries use more energy when they are travelling fast?

b Why do the lorries use more energy when they are travelling faster?

4 Look at the pictures of the two lorries.

a Describe what is different between the two lorries.

b Explain how this difference will affect the drag of the lorries.

c Does Lorry A belong to Daisy or Fred? Explain your answer.

5 Lorry A goes on a journey, and manages a mean speed of 50 mph. Its fuel consumption for the trip is 1.1 miles per litre. Why do you think its fuel consumption is different to the value given in the table?

6 The information in the table shows the fuel consumption when the lorries are fully loaded.

a How would the amount of energy used by the lorries change when they are empty?

b How will this affect the number of miles they can travel for each litre of fuel?

c Sketch another line on your graph to show what the fuel consumption for Lorry B might be when it is not carrying a load.

7 What are the advantages of reducing the fuel consumption of lorries or other vehicles? Give as many reasons as you can.

I can…

- apply ideas about balanced and unbalanced forces to real-life situations
- explain how fuel consumption is affected by streamlining and speed.

How big is the force of air resistance on a moving car? This question is important to designers, because they need to try to make the air resistance as small as possible. However, it is not a simple question to answer, because the size of the force depends on the size and shape of the vehicle, the speed it is moving, and the density of the air it is moving through. The drag force at a particular speed can be calculated using this formula:

$D = \frac{1}{2} \times \rho \times V^2 \times C_d \times S$ (You do not need to remember this formula!)

Where:

D is the drag force on the vehicle.

ρ is the Greek letter 'rho' and represents the density of air (about 1.225 kg/m^3 at sea level).

V is the speed of the vehicle in metres per second.

C_d is called the coefficient of drag. It depends on the shape of the vehicle and it is usually found using measurements made in a wind tunnel. For a car, the coefficient of drag is usually between 0.4 and 0.5. Cars with good streamlined shapes have low drag coefficients.

S is the area of the car that faces the oncoming air.

We can use the formula to help us to work out which variables have the most effect on the drag force on the car.

1 Work out the drag force on a car at speeds from 10 mph to 70 mph, in 10 mph intervals. Present your results in a table. You will need to use the information above. Assume that the car has a C_d of 0.45 and a front area of 2 m^2. You can convert mph into m/s by dividing by 2.237. You can use a spreadsheet for this if you have access to a computer.

2 Plot a graph to show the drag on the car. Put speed on the horizontal axis.

3 How is the drag affected if you double:

a the speed of the car

b the frontal area of the car?

c Explain how you worked out your answers to parts **a** and **b**.

4 What causes the drag force? Use ideas about particles in your answer.

5 Why do you think the drag force on a car depends on the density of the air? Explain as fully as you can. (*Hint*: you need to think about what density means in terms of how many air particles there are in a particular volume of air.)

6 In some countries the land is thousands of feet above sea level, so the air density is less. Air density also decreases when the air is hot. What effect would these changes in density have on the drag force on a car? Explain your answer.

7 Sometimes people put roof racks on their cars so they can carry more luggage.

a What effect will a roof rack have on the drag force?

b Would adding a roof rack increase or decrease the coefficient of drag of a car?

I can…

- use calculations to explore how different variables affect air resistance
- plot a scatter graph
- use the particle model to explain drag.