7.2.1 States of matter

102 minutes

128 marks

##

Stars such as the Sun are formed from vast and diffuse clouds of gas and dust. The clouds contract to form stars as gravity pulls the gas and dust together.

(a) As a cloud contracts, it becomes hotter. Explain why, in terms of the movement of gas molecules in the cloud.

.....

.....

2 marks

(b) In the later stages of collapse, the contraction of the cloud is slowed down by a number of factors. Suggest **one** factor which would slow down the contraction of the cloud.

.....

1 mark

(c) What are the main processes by which energy is transferred into space from the hot centre of the collapsed cloud? State where these processes occur.

.....

.....

2 marks

(d) Before nuclear fusion begins, the contracting cloud is very much more difficult to observe than stars which are the same distance away.

Explain why the cloud is difficult to observe.

.....

.....

1 mark

(e) What is the most abundant chemical element in the cloud?

.....

1 mark

(f) Eventually the temperature at the centre of the cloud becomes high enough for nuclear fusion to begin. What happens during nuclear fusion?

.....

1 mark

Maximum 8 marks

##

The porous pot shown in diagrams 1 and 2 lets gas molecules pass through the walls. In diagram 2 a beaker containing hydrogen is placed over the porous pot. The water levels in the U-tube quickly change.

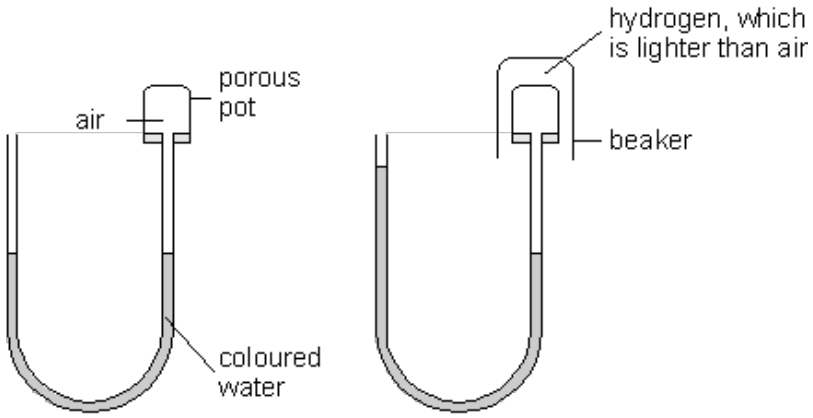


diagram 1 diagram 2

Four statements about the movement of gas molecules are given below.

A – no molecules are moving into or moving out of the porous pot

B – same number of gas molecules are moving into the porous pot as are moving out

C – more gas molecules are moving into the porous pot than are moving out

D – fewer gas molecules are moving into the porous pot than are moving out

(a) Which statement, A, B, C or D, applies to:

(i) Diagram 1? .....

1 mark

(ii) Diagram 2 just after the beaker is put in position?.....

1 mark

(b) What does the experiment suggest about the average speed of hydrogen molecules compared with the average speed of molecules in the air?

Hydrogen molecules .....

1 mark

(c) The beaker is removed from around the porous pot.

(i) How does the water level in the left hand part of the U-tube change?

.....

1 mark

(ii) Explain your answer in terms of the movement of molecules.

.....

.....

1 mark

(d) Air contains oxygen, nitrogen, argon, some water vapour, and a little carbon dioxide.

Complete each row in the following table by ticking one box and by stating the number of atoms in one molecule of the substance.

The first row has been done for you.

substance	it is an element	it is a compound	it is a mixture	number of atoms in one molecule
nitrogen	✓			2
carbon dioxide				
oxygen				

4 marks

Maximum 9 marks

##

(a) The table shows some of the properties of three different substances, X, Y and Z. Complete the last column by stating whether each substance is a metal, a non-metal or a compound.

substance	melting point	electrical conductivity	solubility in water	effect of heating in air	metal or non–metal or compound
X	113 °C	very poor	insoluble	burns to form one product which is an acidic gas	
Y	962 °C	very good	insoluble	loses shiny surface	
Z	–182 °C	very poor	almost insoluble	burns to form two new substances	

3 marks

(b) Complete the following using **one** of the phrases.

Closer together **further apart** **in contact with more particles**

Substance Z has a boiling point of –161°C. At room temperature the

particles of Z are ..... than the particles of substance X.

1 mark

(c) Substance Z burns in air. What must be present in air for substance Z to burn?

.....

1 mark

Maximum 5 marks

Q4. Air is a gas at room temperature. The chemical formulae below show some of the substances in the air.

Ar CO_2 H_2O N_2 Ne O_2

(a) Put these formulae in the correct columns in table A to show which substances are elements and which are compounds.

table A

element	compound

1 mark

(b) Put the formulae in the correct columns in table B to show whether the formula of each substance represents an atom or a molecule.

table B

atom	molecule

1 mark

(c) The coldest possible temperature is 'absolute zero', which is –273°C. As air is cooled towards absolute zero it liquefies. Table C gives the boiling points of the substances in air.

table C

formula	boiling point in °C
Ar	–186
CO_2	–78
H_2O	100
N_2	–196
Ne	–246
O_2	–183

A sample of air at a temperature close to absolute zero is allowed to warm up.
Which substance boils first?

.....

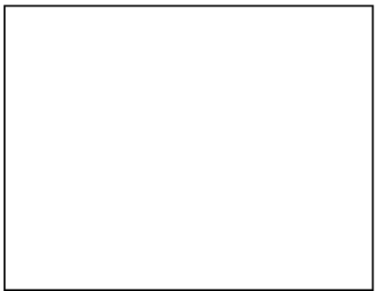
1 mark

(d) Each particle of neon can be represented by a circle.

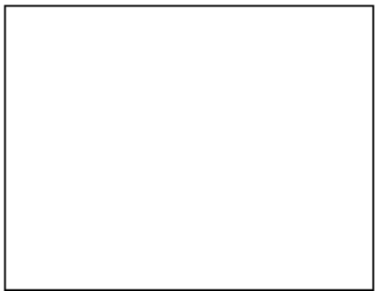
Carefully complete the diagrams below to show the arrangement of particles in neon gas and liquid neon.

Use circles about ◯ in size.

neon gas, Ne



liquid neon, Ne



4 marks
Maximum 7 marks

Q5. (a) Potassium nitrate (KNO_3) can be made by reacting 'potash' (K_2CO_3) with nitric acid (HNO_3).

(i) What is the chemical name for 'potash' (K_2CO_3)?

.....

1 mark

(ii) Write a balanced equation for the reaction of 'potash' with nitric acid.

.....

3 marks

(b) Potassium nitrate is used in airbags, which are part of the safety equipment of modern cars.
Inside an airbag, potassium nitrate is mixed with sodium azide.
When there is an accident, a spark makes the chemicals react.

(i) Firstly, the solid sodium azide (NaN_3) decomposes to produce sodium and nitrogen gas (N_2). Write a balanced symbol equation for this reaction.

.....

1 mark

(ii) Next, the sodium reacts with the potassium nitrate to form more nitrogen gas. The nitrogen inflates the nylon airbag.

Explain, in terms of molecules, why the formation of nitrogen gas makes the bag inflate.

.....

.....

.....

2 marks

(iii) Why is it important that there is **no** sodium left after the reactions?

.....

.....

1 mark

(c) (i) As the driver is thrown forward against the bag, the gas pressure in the bag increases. Explain why it increases.

.....

.....

1 mark

(ii) There are tiny holes in the bag which allow a small volume of the gas to escape.

How does this prevent injury to the driver?

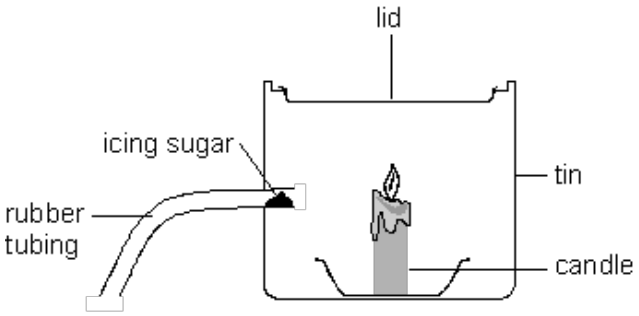
.....

.....

1 mark

Maximum 10 marks

Q6. A teacher set up the following apparatus behind a safety screen.
She placed 1 g of icing sugar in the end of the rubber tubing inside the tin, as shown below.



The teacher blew through the other end of the rubber tubing.
The icing sugar came into contact with the flame.
There was a loud explosion and the lid was blown off the tin.

(a) Complete the following sentence describing the energy changes which took place.

..... energy in the icing sugar changed to

..... energy and ..... energy.

3 marks

(b) As a result of the explosion, the lid of the tin was pushed off.
Explain what had happened to the gas molecules inside the tin to make this happen.

.....

.....

.....

.....

2 marks

(c) When icing sugar is burned in this experiment, the gas **used** and the gas **produced** are the same as when energy is released from sugar in the cells of the body.

(i) Which gas, in the air, is **used** when the icing sugar burns?

.....

1 mark

(ii) Give the name of the gas **produced** when the icing sugar burns.

.....

1 mark

(d) The table below shows the energy values of four food substances.

food substance	energy value, in kJ per 100 g
icing sugar	1680
curry powder	979
flour	1450
custard powder	630

The teacher repeated the experiment with 1 g of custard powder.
What difference would this make to the experiment?

.....

.....

1 mark
Maximum 8 marks

Q7. The list below shows properties that different elements can have.

- magnetic
- can be compressed
- very high melting point
- very low melting point
- good conductor of heat
- poor conductor of heat
- good conductor of electricity
- poor conductor of electricity

(a) Which **two** properties from the list above make aluminium suitable for saucepans?

1. .....

2. .....

2 marks

(b) Which property in the list above explains why:

(i) copper is used in the cable of a television?

.....

1 mark

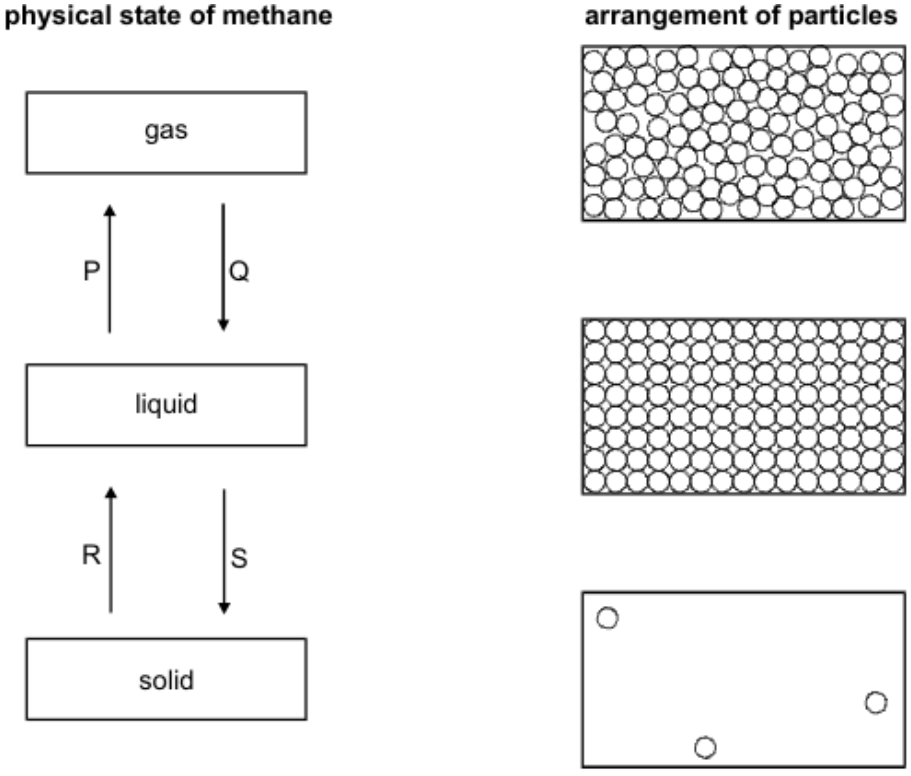
(ii) a lot of oxygen gas can be pumped into a very small container?

.....

1 mark
Maximum 4 marks

Q8. (a) Methane can be a gas, a liquid or a solid. In the diagram below, arrows P, Q, R and S represent changes of state.

The boxes on the right show the arrangement of particles of methane in the three different physical states.
Each circle represents a particle of methane.



(i) Draw a line from each physical state of methane to the arrangement of particles in that physical state.
Draw only **three** lines.

1 mark

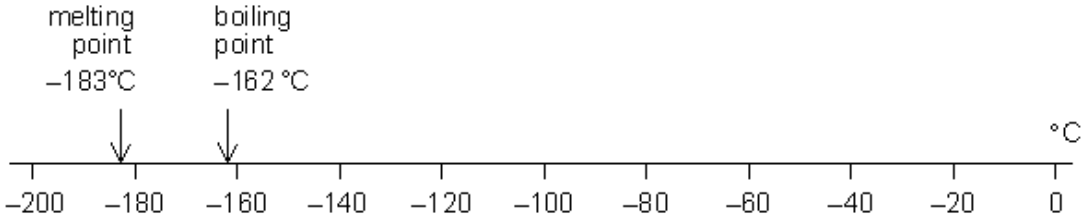
(ii) Arrows P, Q, R and S represent changes of state.
Which arrow represents:

evaporation? .....

melting? .....

2 marks

(b) Methane is the main compound in natural gas. The scale below shows the melting point and the boiling point of methane.



Methane has three physical states: solid, liquid and gas.

(i) What is the physical state of methane at –170°C?

.....

1 mark

(ii) The formula of methane is CH_4. The symbols for the two elements in methane are C and H.

Give the names of these two elements.

element C .....

element H .....

2 marks

(iii) When methane burns, it reacts with oxygen.
One of the products is water, H_2O.

Give the name of the other product.

.....

1 mark
Maximum 7 marks

Q9. The table below gives information about three fuels that can be used in cars.

✓ shows a substance is produced when the fuel burns.
X shows a substance is **not** produced when the fuel burns.

fuel	physical state	energy released, in kJ/kg	some of the substances produced when the fuel burns		
			carbon monoxide	sulphur dioxide	water
petrol	liquid	48 000	✓	✓	✓
hydrogen	gas	121 000	**X**	**X**	✓
ethanol (alcohol)	liquid	30 000	✓	**X**	✓

(a) Which fuel, in the table, releases the **least** energy per kilogram (kg)?

.....

1 mark

(b) Some scientists say that if hydrogen is burned as a fuel there will be less pollution.
From the information in the table, give **one** reason why there will be less pollution.

.....

.....

1 mark

(c) Which of the three **fuels** in the table can be compressed into a small container?

.....

1 mark

(d) Which gas in the air is needed for fuels to burn?
Tick the correct box.

carbon dioxide ☐

nitrogen ☐

oxygen ☐

water vapour ☐

1 mark

(e) Petrol and ethanol are both fuels. Petrol is made from oil.
Scientists say that oil could run out in 100 years.
In some countries people plant sugar cane and use it to make ethanol.

Sugar cane will **not** run out. Explain why.

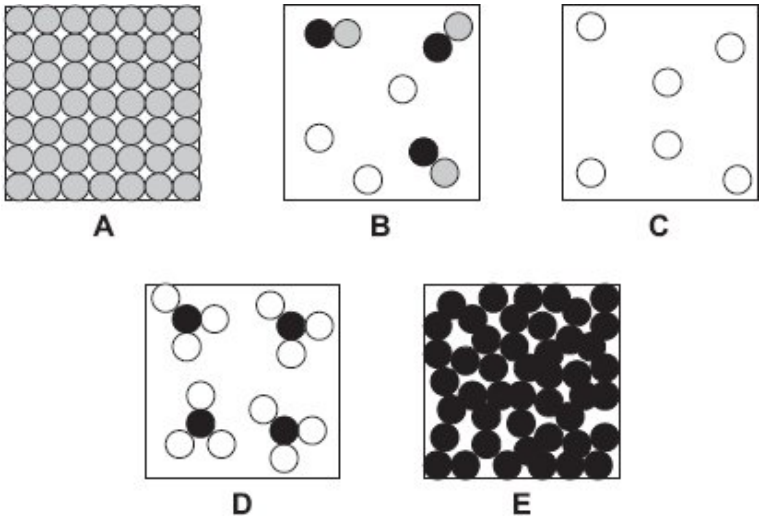
.....

.....

1 mark
Maximum 5 marks

Q10. (a) The diagrams below show the arrangement of atoms or molecules in five different substances A, B, C, D and E.

Each of the circles ○, ○ and ● represents an atom of a different element.



Give the letter of the diagram which represents:

(i) a mixture of gases;

.....

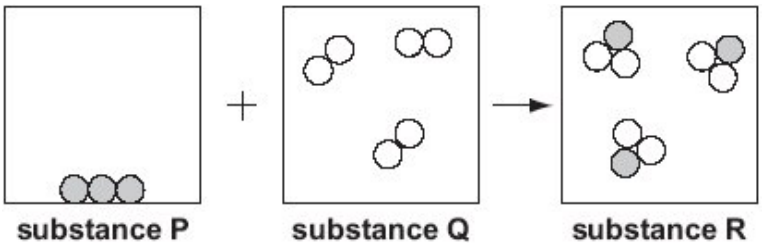
1 mark

(ii) a single compound.

.....

1 mark

(b) The diagram below shows a model of a chemical reaction between two substances.



(i) How can you tell from the diagram that a chemical reaction took place between substance P and substance Q?

.....

.....

1 mark

(ii) Substance P is carbon.

Suggest what substances Q and R could be.

substance Q .....

substance R .....

1 mark

(iii) How does the diagram show that mass has been conserved in this reaction?

.....

.....

1 mark
maximum 5 marks

Q11. (a) (i) Air contains nitrogen.

In the box below draw **five** circles, ◯, to show the arrangement of particles in nitrogen gas.

1 mark

(ii) Zeena carries a personal emergency alarm.
It uses nitrogen gas to produce a very loud sound.

The nitrogen gas in the container is under much higher pressure than the nitrogen gas in the air.

How does the arrangement of nitrogen particles change when the gas is under higher pressure?

.....

.....

1 mark

(b) Use words from the boxes below to complete the sentence.

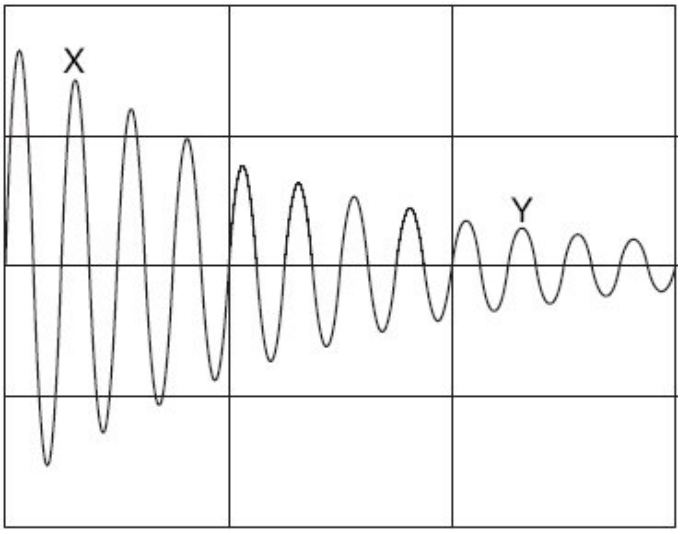
greater than	less than	the same as

The rate at which the nitrogen particles hit the inside of the container is ..... the rate at which nitrogen particles hit the outside of the container.

1 mark

(c) Zeena pushes the lid down and nitrogen gas escapes through the diaphragm. The diaphragm vibrates and produces a sound.

The pattern on the oscilloscope screen below represents the soundwave produced by the alarm.



(i) The loudness of the sound produced by the alarm decreases between X and Y.

How can you tell this from the graph?

.....

.....

1 mark

(ii) The pitch of the sound produced by the alarm stays the same between X and Y.

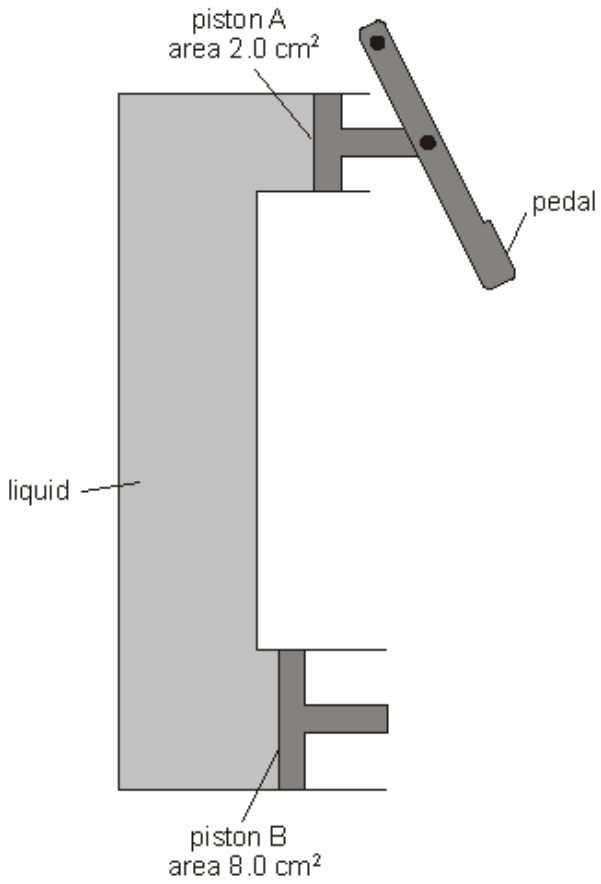
How can you tell this from the graph?

.....

.....

1 mark
maximum 5 marks

Q12. The diagram below shows a container filled with a liquid.



At each end of the container there is a piston.
Piston A has a smaller area than piston B.

(a) (i) Rebekah pushes on the pedal. This produces a force of 200 N on piston A.

Calculate the pressure that piston A exerts on the liquid.
Give the unit.

.....

.....

2 marks

(ii) The liquid in the container exerts the same pressure on piston B.

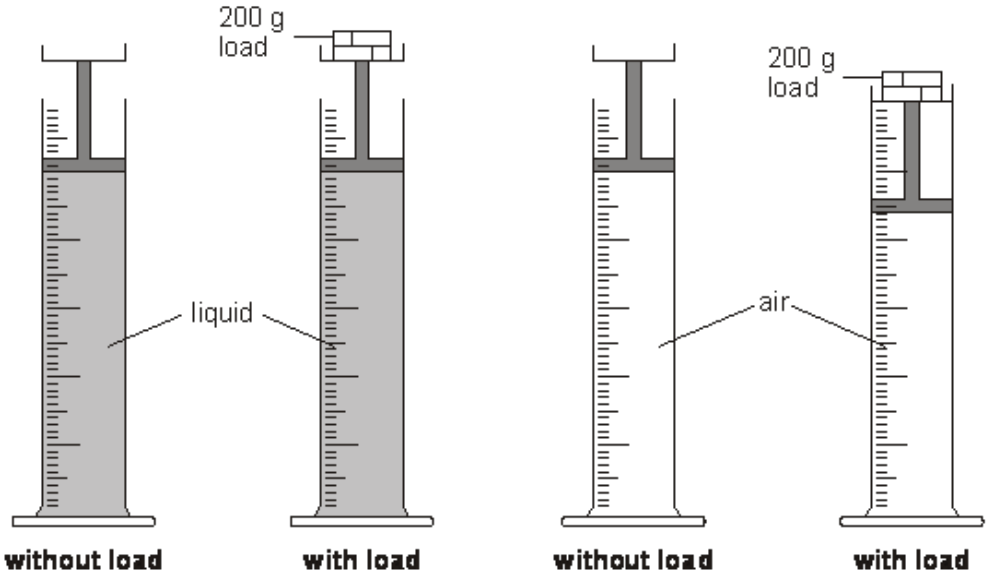
Use this pressure to calculate the force on piston B.

.....

..... N

1 mark

(b) Rebekah set up a different experiment as shown below.
She measured the volume of the liquid and the air in the cylinders before and after a 200 g load was added to the piston.



(i) When the loads were added to the pistons, the volume of the liquid did **not** change but the volume of the air decreased.

Explain why this happened.

.....

.....

1 mark

(ii) The diagram on the opposite page represents the way the brake system of a car works.
The brake pedal pushes piston A.
Piston B pushes the brakes on.

If air bubbles get into the liquid, the brakes do **not** work properly.
Explain why.
Use the diagrams above to help you.

.....

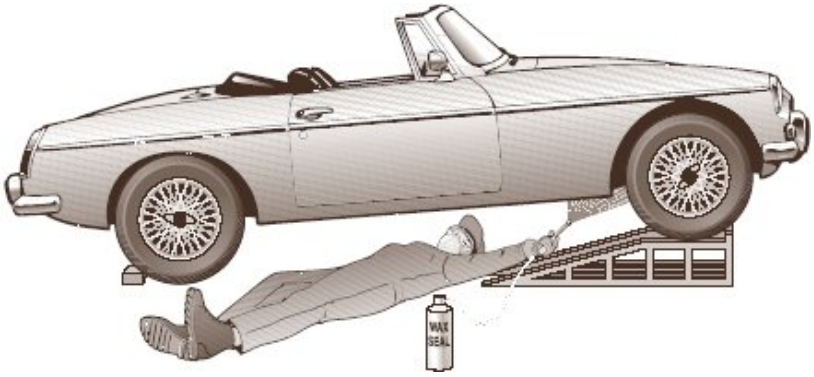
.....

1 mark
maximum 5 marks

Q13. Jill bought a can of Wax Seal to spray the parts underneath her car.

Wax Seal helps to prevent these parts rusting.

It is a mixture of wax and a liquid called white spirit.



(a) (i) The body of Jill's car is made from steel. Steel contains iron.

Give **two** substances that are needed for iron to rust.

1. .....

1 mark

2. .....

1 mark

(ii) How does Wax Seal help to protect the car from rusting?

.....

.....

1 mark

(iii) Wax Seal can also be used on the upper parts of a car.

What else protects parts such as the doors from rusting?

.....

1 mark

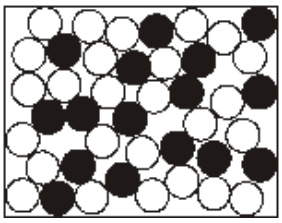
(b) The metal parts of a car may corrode.

What type of air pollution could cause corrosion?

.....

1 mark

(c) The diagram below shows the mixture of particles of wax and white spirit in Wax Seal.



not to scale

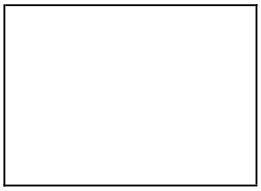
After Jill sprays the car, the white spirit evaporates leaving a layer of solid wax on the surface.

(i) In the box below, draw **eight** circles, ○, to show the arrangement of particles in a gas.

particles in a **gas**

1 mark

(ii) In the box below, draw **eight** circles, ●, to show the arrangement of particles in a solid.



particles in a **solid**

1 mark
maximum 7 marks

Q14. Diagram **A** represents a gas in a container.
The gas can be compressed by moving the piston to the right.

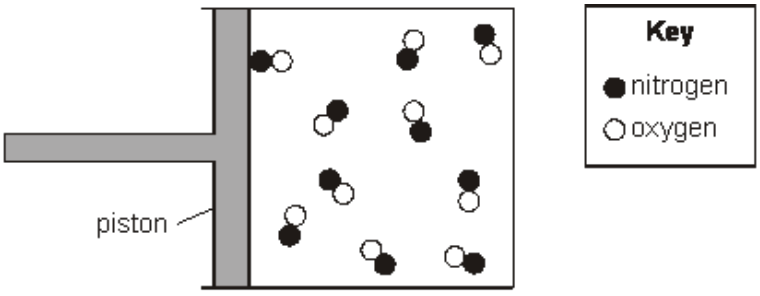


diagram A

(a) (i) How can you tell that the substance in the container is a gas?

.....

.....

1 mark

(ii) How can you tell from the diagram that the gas is pure?

.....

.....

1 mark

(b) The piston is moved to the right as shown in diagram **B**.

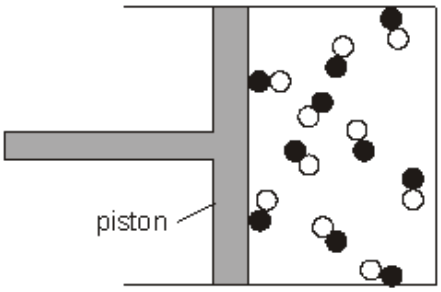


diagram B

How can you tell, from diagram **B**, that the pressure of the gas has increased?

.....

.....

1 mark

(c) Diagram **C** shows what happened to the molecules after the gas was compressed more.

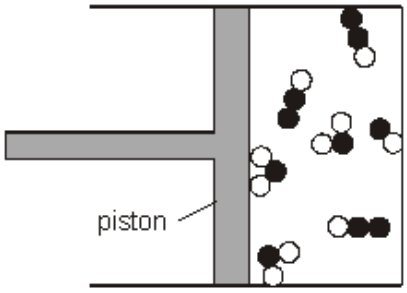


diagram C

(i) How can you tell that a chemical reaction happened when the gas was compressed?

.....

.....

1 mark

(ii) The mass of the gas in both diagrams **B** and **C** was 0.3 g.

Why did the mass of the gas **not** change when it was compressed?

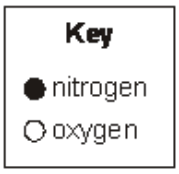
.....

.....

1 mark

(iii) Complete the table below with the correct chemical formula of each substance. Use the key to help you.

substance	formula
	
	
	



1 mark

(iv) What is the **name** of the substance represented by the symbol  ?

.....

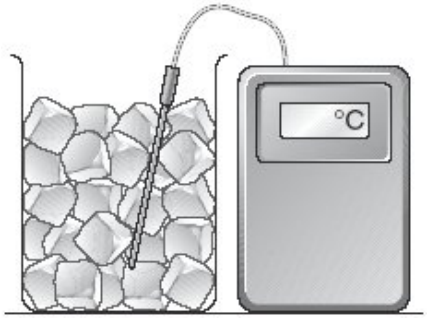
1 mark
maximum 7 marks

Q15. (a) Draw a line from each change of state to the correct name.
Draw only **four** lines.

change of state	name
solid to liquid	evaporating
liquid to gas	melting
gas to liquid	condensing
liquid to solid	freezing

3 marks

(b) Kate made some ice cubes from pure water.
She used a sensor to measure the temperature of the ice.



What temperature will the sensor show when the ice is melting?

..... °C

1 mark

(c) Kate made some more ice cubes from salt solutions. She used a different amount of salt in each ice cube.

The table shows the temperature at which the ice cubes melted.

mass of salt in each ice cube (g)	temperature ice cube melted (°C)
5	−4
10	−8
15	−11
20	−15

Look at the table above.
As the mass of salt increased, what happened to the temperature at which the ice cube melted?

.....

1 mark

(d) In very cold weather a mixture of salt and sand is spread on roads.

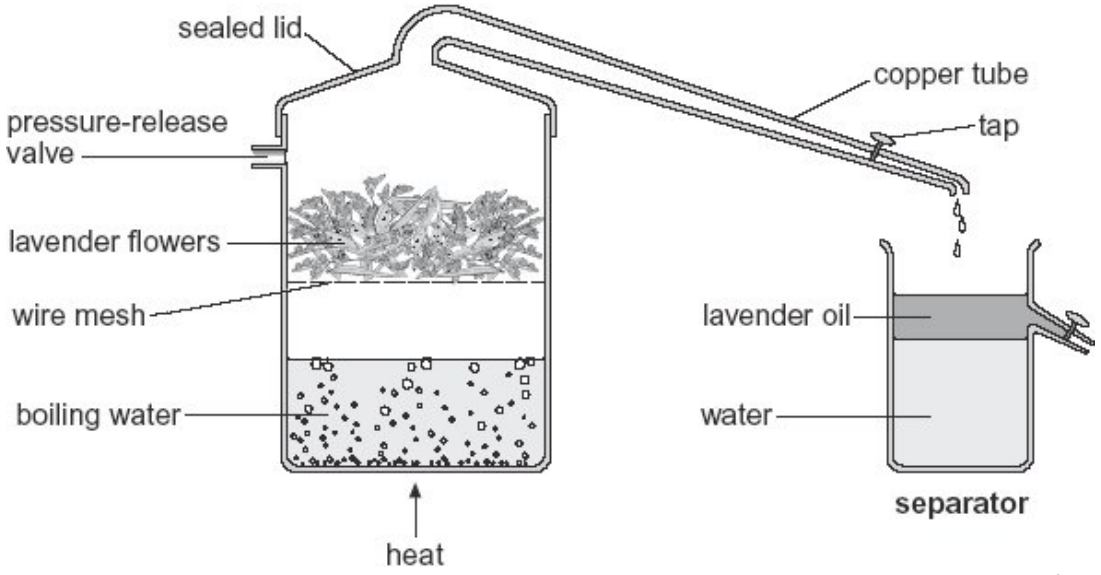
Why are salt **and** sand used?
Tick the **two** correct boxes.

Salt makes the roads white.	☐	Sand dissolves in water.	☐
Salt makes water freeze.	☐	Sand increases friction between car tyres and the road.	☐
Salt makes ice melt.	☐	Sand makes water freeze.	☐

2 marks
maximum 7 marks

##

Lavender oil is a perfume obtained from lavender flowers.
Steam at 100°C is passed through the flowers in the apparatus below.



not to scale

Water vapour and lavender oil vapour pass down a copper tube towards a separator.

(a) (i) The lavender flowers are heated in a container with a sealed lid.

Why must the lid be sealed?

.....

.....

1 mark

(ii) What would happen if the container did **not** have a pressure-release valve?

.....

.....

1 mark

(b) Lavender oil vapour and water vapour cool as they pass down the copper tube. A mixture of lavender oil and water collects in the separator.

(i) What is the change in the physical state of both lavender oil vapour and water vapour as they cool?

from ..... to .....

1 mark

(ii) Look at the separator.

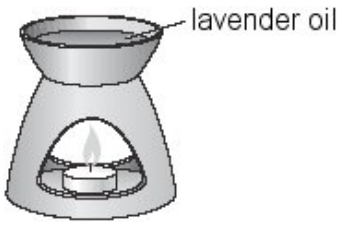
How does this show that the water is denser than lavender oil?

.....

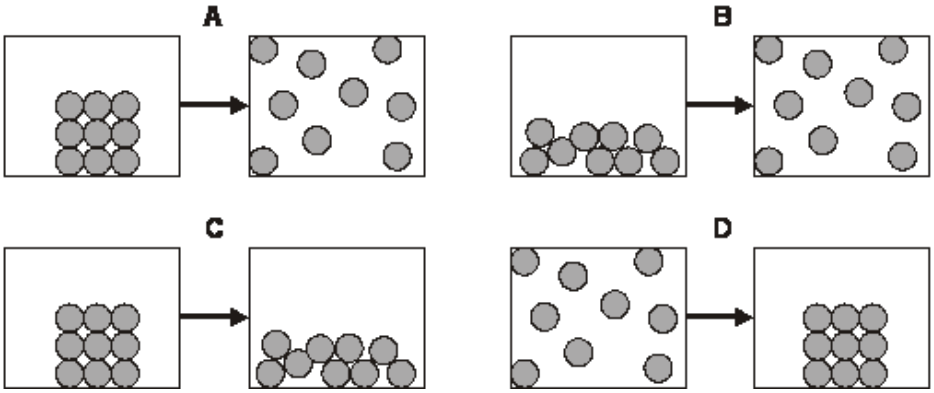
.....

1 mark

(c) Rosie poured some lavender oil into an oil burner.
She heated it with a candle.



The oil changed state.



Which diagram represents this change of state?
Write the letter.

.....

1 mark
maximum 5 marks

Q17. (a) The table below shows the melting points and boiling points of four elements.

element	melting point (°C)	boiling point (°C)
aluminium	660	2520
iron	1540	2760
magnesium	650	1100
mercury	−39	357

When answering the questions below, you may give the name of an element more than once.

Which element in the table is:

(i) a liquid at 0°C?

.....

1 mark

(ii) a solid at 1500°C?

.....

1 mark

(iii) a gas at 500°C?

.....

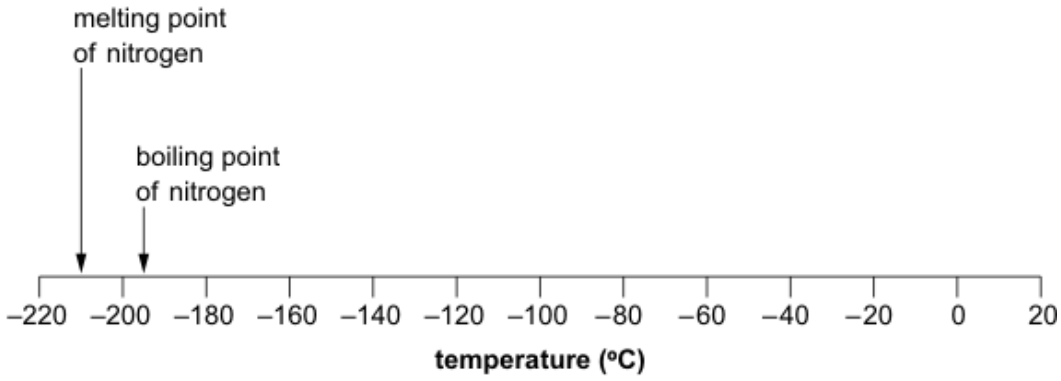
1 mark

(iv) a liquid over the biggest temperature range?

.....

1 mark

(b) The melting point and boiling point of nitrogen are marked on the scale below.



(i) **Draw an arrow** on the scale above to show the temperature at which water freezes.

1 mark

(ii) When water is a liquid, what is the physical state of nitrogen?
Tick the correct box.

solid ☐ liquid ☐ gas ☐

1 mark

(iii) What is the physical state of nitrogen at −200°C?
Tick the correct box.

solid ☐ liquid ☐ gas ☐

1 mark
maximum 7 marks

Q18. Stefan is on holiday in the mountains. It is snowing.

(a) (i) Choose words from the box to complete the sentence below.

solid	**liquid**	**gas**

A snowflake falls on Stefan's nose and melts.
When the snowflake melts, it changes

from a ..... to a ..... .

1 mark

(ii) Snow that falls on the ground melts slowly.
Snow that falls on Stefan's nose melts **very quickly**.
Give a reason for this.

.....

1 mark

(iii) In his hotel, Stefan sees some changes.
Are the changes below reversible?
Write **yes** or **no**.

ice melting .....

wood burning .....

toasting bread .....

1 mark

(b) (i) Stefan is snowboarding. Gravity acts on Stefan.
On the diagram below, draw an arrow to show the direction of the force of gravity.

1 mark

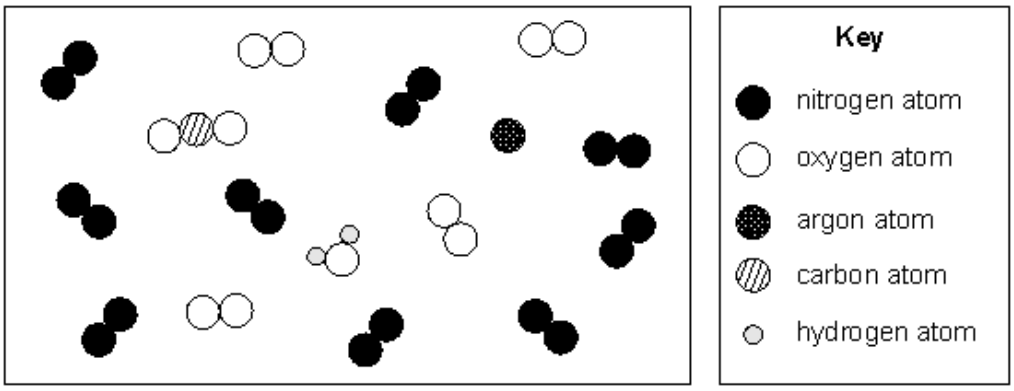
(ii) When Stefan wants to slow down, he pushes one edge of the snowboard into the snow.

What force between the board and the snow makes him slow down?

.....

1 mark
maximum 5 marks

Q19. The diagram below represents the particles found in air.



(a) Complete the following table. Use the diagram and key above to help you.

name	symbol	chemical formula
argon		Ar
nitrogen		
oxygen		O_2
		

3 marks

(b) Air is a **gas** at room temperature.
What evidence in the diagram above shows this?

.....

1 mark

(c) A sample of air in a balloon is cooled.
Complete the sentences below using words from the box.
You may use each word more than once.

increases	**decreases**	**stay the same**

When the air is cooled, the volume of the air ..... and

the mass of the air ..... .

When the air is cooled, the density of the air ..... .

1 mark

(d) In 1902, the scientist Carl von Linde cooled air to produce **liquid oxygen**.

The table below shows the melting points and boiling points of four substances that are found in air.

substance	melting point (°C)	boiling point (°C)
argon	–189	–186
oxygen	–218	–183
nitrogen	–210	–196
water	0	100

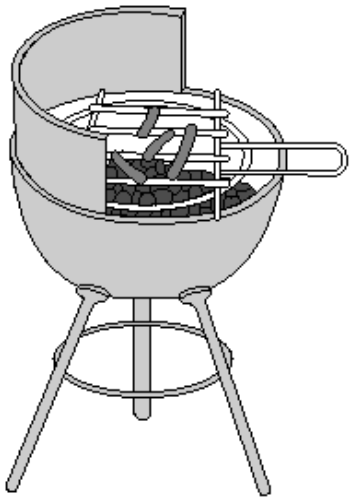
Before Linde, scientists tried to produce **liquid air** by cooling it to –190°C.
Give a reason why liquid air was not produced.

.....

.....

1 mark
maximum 6 marks

Q20. Susie cooked sausages on a barbecue.



(a) Fat and water in the sausages changed state.

Draw **one** line from each statement to the correct change of state.
Draw only **two** lines.

statement	**change of state**
	liquid to gas
fat melted	gas to liquid
	liquid to solid
water evaporated	solid to liquid
	solid to gas

2 marks

(b) Susie uses charcoal as the fuel for the barbecue.

(i) Which statement is true about all fuels?
Tick the correct box.

All fuels are sources of energy.	☐	All fuels are black.	☐
All fuels are made from wood.	☐	All fuels are solid.	☐

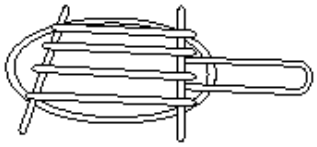
1 mark

(ii) Which gas in the air is needed for fuels to burn?
Tick the correct box.

water vapour	☐	oxygen	☐
nitrogen	☐	carbon dioxide	☐

1 mark

(c) The metal grill of the barbecue is made of steel.



Six properties of steel are given below.

Which properties are needed for the metal grill?
Tick **two** correct boxes.

It conducts electricity.	☐	It is rigid.	☐
It has a very high melting point.	☐	It is magnetic.	☐
It is shiny.	☐	It rusts.	☐

2 marks
maximum 6 marks