IGCSE · Cambridge (CIE) · Chemistry

3 hours 19 questions

Theory Questions

Solids, liquids & gases

Kinetic Theory / States of Matter / Pressure & Temperature in Gases / Diffusion

Easy (7 questions)	/42
Medium (6 questions)	/63
Hard (6 questions)	/61
Total Marks	**/166**

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Easy Questions

1 (a) Separate: Chemistry and Extended Only

The following table gives information about six substances.

Substance	melting point / °C	boiling point /°C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	-210	-196	poor	poor
C	776	1497	poor	good
D	-117	78	poor	poor
E	1607	2227	poor	poor
F	-5	102	poor	good

Which substance could have a macromolecular structure, similar to that of silicon(IV) oxide?

.....

(1 mark)

(b) Which substances are solids at room temperature?

.....

(1 mark)

(c) Extended Only

Which substance could be a metal?

.....

(1 mark)

(d) Extended Only

Which substance could be aqueous sodium chloride?

.....

(1 mark)

(e) Extended Only

Which substance is an ionic compound?

.....

(1 mark)

(f) Which substances are liquids at room temperature?

.....

(1 mark)

2 (a) Extended Only

Explain the following in terms of the kinetic particle theory.

The rate of most reactions increases at higher temperatures.

(3 marks)

(b) Extended Only

Explain the following in terms of the kinetic particle theory.

A liquid has a fixed volume but takes up the shape of the container. A gas takes up the shape of the container but it does not have a fixed volume.

(3 marks)

3 The table shows the melting points, boiling points and electrical properties of the six substances **A** to **F**.

substance	melting point / ^{o}C	boiling point / ^{o}C	electrical conductor at room temperature	electrical conductor of substance dissolved in water
A	961	2193	good	does not dissolve
B	113	444	does not conduct	does not dissolve
C	0	100	very poor	very poor
D	803	1465	does not conduct	good
E	-5 to-1	102-105	good	good
F	-8	-6	does not conduct	does not dissolve

i) Which **three** substances are solids at room temperature?

[1]

ii) Which **one** is an ionic compound?

[1]

iii) Which **one** is a gas at room temperature?

[1]

iv) Which **two** substances are liquids at room temperature?

[1]

v) Which **one** substance is a metal?

[1]

vi) Which **one** is an impure substance?

[1]

(6 marks)

4 (a) Give the name of the process that occurs when a gas turns into a liquid.

.....

(1 mark)

(b) Give the name of the process that occurs when a solid turns into a gas without first forming a liquid.

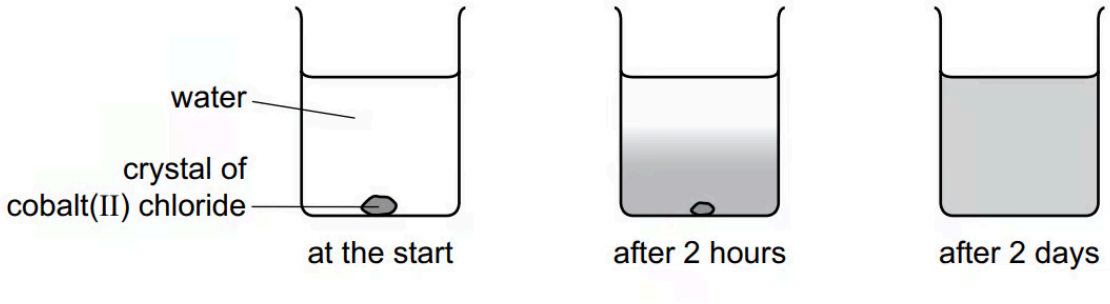
.....

(1 mark)

(c) **Figure 1.2** shows a coloured crystal of cobalt(II) chloride is placed at the bottom of a beaker containing water.

After two days, the colour has spread throughout the water.

Figure 1.2



Explain these observations.

.....

.....

.....

(3 marks)

5 (a) Complete **Table 1.1** about solids, liquids and gases.

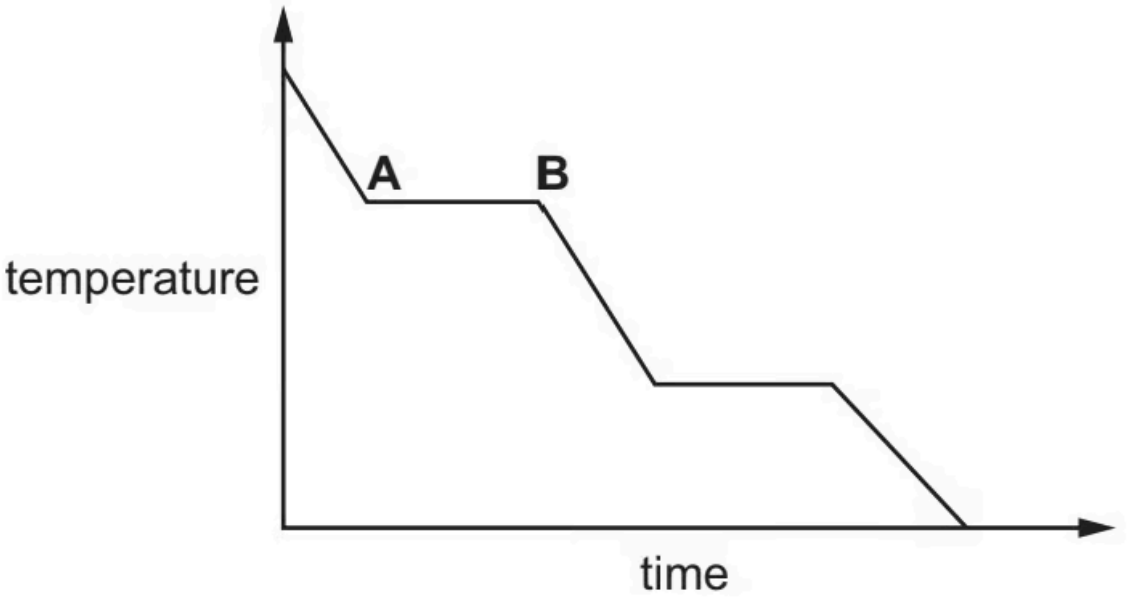
Table 1.1

	particle separation	particle arrangement	type of motion
solid		regular	vibrate only
liquid	some touching		random
gas	apart	random	

(3 marks)

(b) Extended Only

The graph shows the change in temperature as a sample of a gas is cooled.



Name the change of state taking place between A and B.

.....

(1 mark)

(c) A bottle of liquid perfume is left open at the front of a room.

After some time, the perfume is smelt at the back of the room.

Name the two physical processes taking place.

.....

.....

(2 marks)

6 (a) This question is about bromine and compounds of bromine.

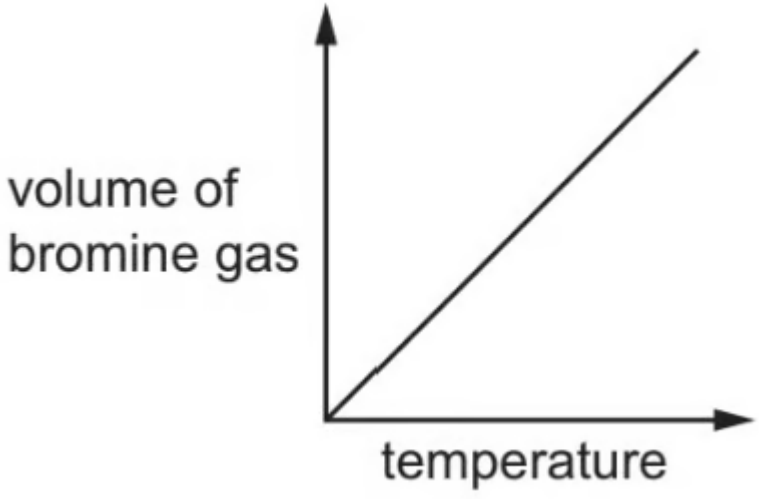
Use the kinetic particle model to describe the arrangement and type of motion of the molecules in:

Liquid bromine:

Bromine gas:

(4 marks)

(b) The graph shows how the volume of bromine gas changes with temperature. The pressure is kept constant.



Describe how the volume of the bromine gas changes with temperature.

(1 mark)

(c) Calcium melts at 839 °C and boils at 1484 °C.

What is the physical state of calcium at 1600 °C?

.....

(1 mark)

7 (a) This question is about chlorine and compounds of chlorine.

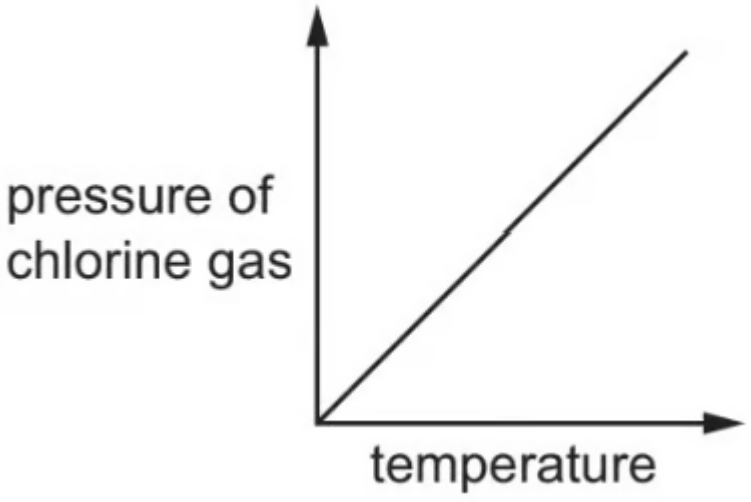
Use the kinetic particle model to describe the arrangement and type of motion of the molecules in:

Solid chlorine:

Chlorine gas:

(4 marks)

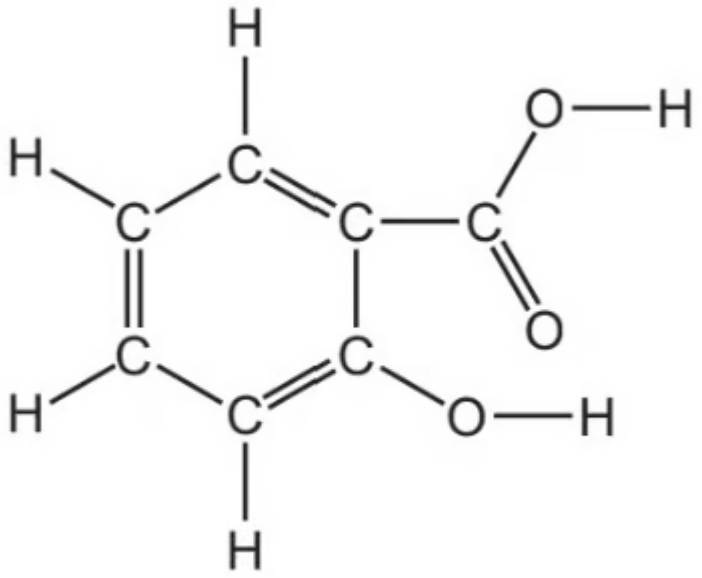
(b) The graph shows how the pressure of chlorine gas changes when temperature increases. The volume is kept constant.



Describe how the pressure of the chlorine gas changes with temperature.

(1 mark)

(c) The structure of compound S is shown.



The melting point of pure S is 159 °C.

The boiling point of pure S is 200 °C.

What is the physical state of pure S at 100 °C?

Explain your answer.

.....

.....

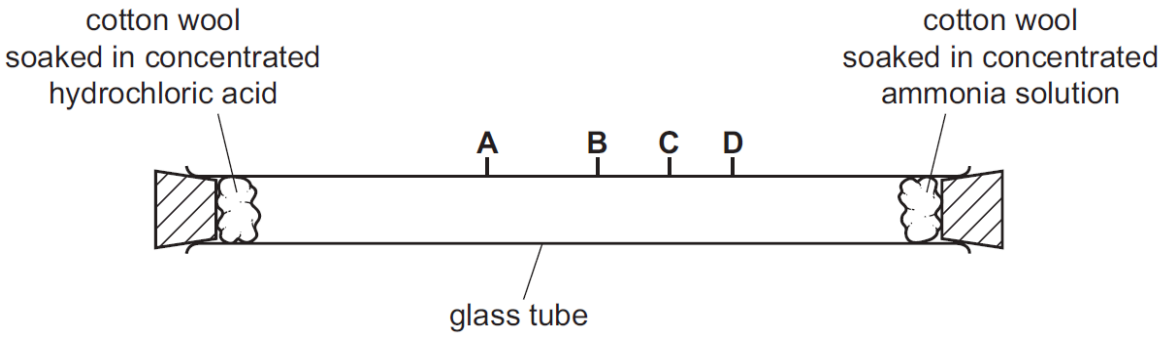
(2 marks)

Medium Questions

1 (a) Extended Only

Concentrated ammonia solution gives off ammonia gas. Concentrated hydrochloric acid gives off hydrogen chloride gas. Ammonia, NH_3, and hydrogen chloride, HCl, are both colourless gases. Ammonia reacts with hydrogen chloride to make the white solid ammonium chloride.

Apparatus is set up as shown.



After ten minutes a white solid forms in the tube where the gases meet.

i) Write the chemical equation for the reaction of ammonia with hydrogen chloride.

[1]

ii) Name the process by which the ammonia and hydrogen chloride gases move in the tube.

[1]

iii) At which point, A, B, C or D, does the white solid form? Explain why the white solid forms at that point.

[3]

iv) The experiment was repeated at a higher temperature. Predict how the results of the experiment would be different. Explain your answer.

[3]

(8 marks)

(b) Some of the white solid is removed from the tube and dissolved in water.

Describe how the white solid could be tested to show it contains:

i) Ammonium ions.

Test .....

Result .....

[3]

ii) Chloride ions.

Test .....

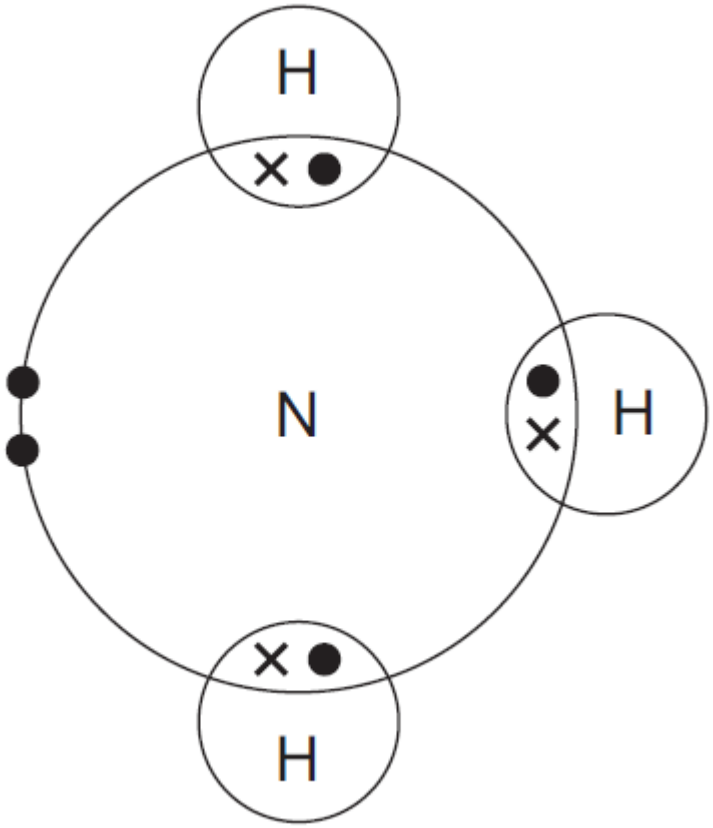
Result .....

[3]

(6 marks)

(c) Extended Only

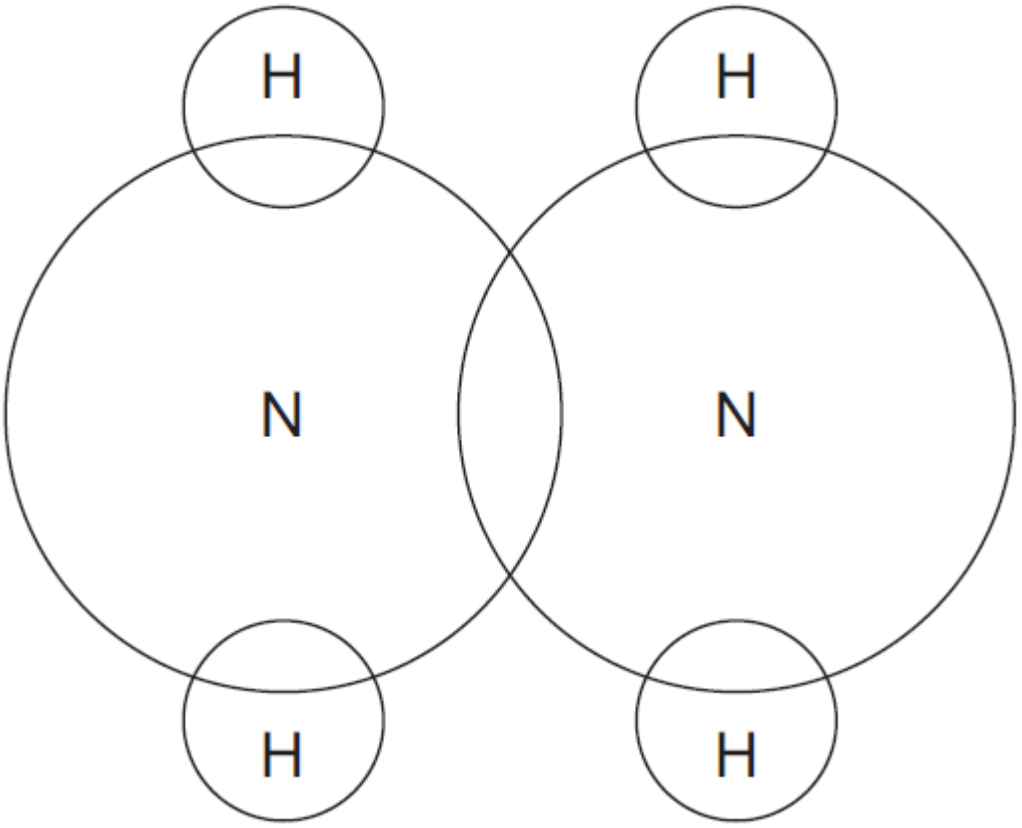
The diagram shows the electron arrangement in a molecule of ammonia, showing only outer shell electrons.



i) State the type of bonding in ammonia.

[1]

ii) Hydrazine, N_2H_4, is another compound of nitrogen and hydrogen. Complete the diagram to show the electron arrangement in a molecule of hydrazine, showing only outer shell electrons.



[3]

(4 marks)

(d) Separate: Chemistry and Extended Only

Nylon and proteins are both polymers containing nitrogen.

i) Name the linkages found in the polymers of nylon and protein.

[1]

ii) Describe one difference in the structures of nylon and protein.

[1]

iii) What is the general name given to the products of hydrolysis of proteins?

[1]

.....

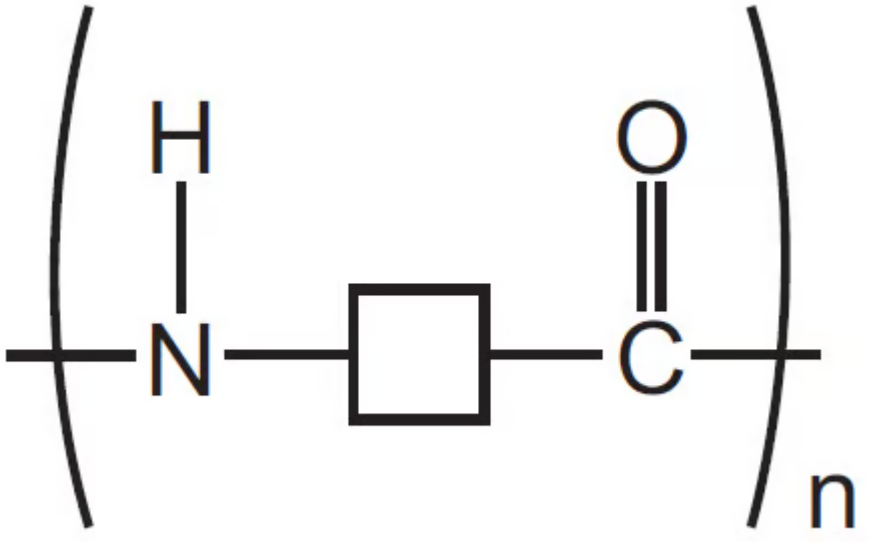
.....

.....

(3 marks)

(e) Extended Only

Suggest the structure of the monomer used to make the polymer shown.



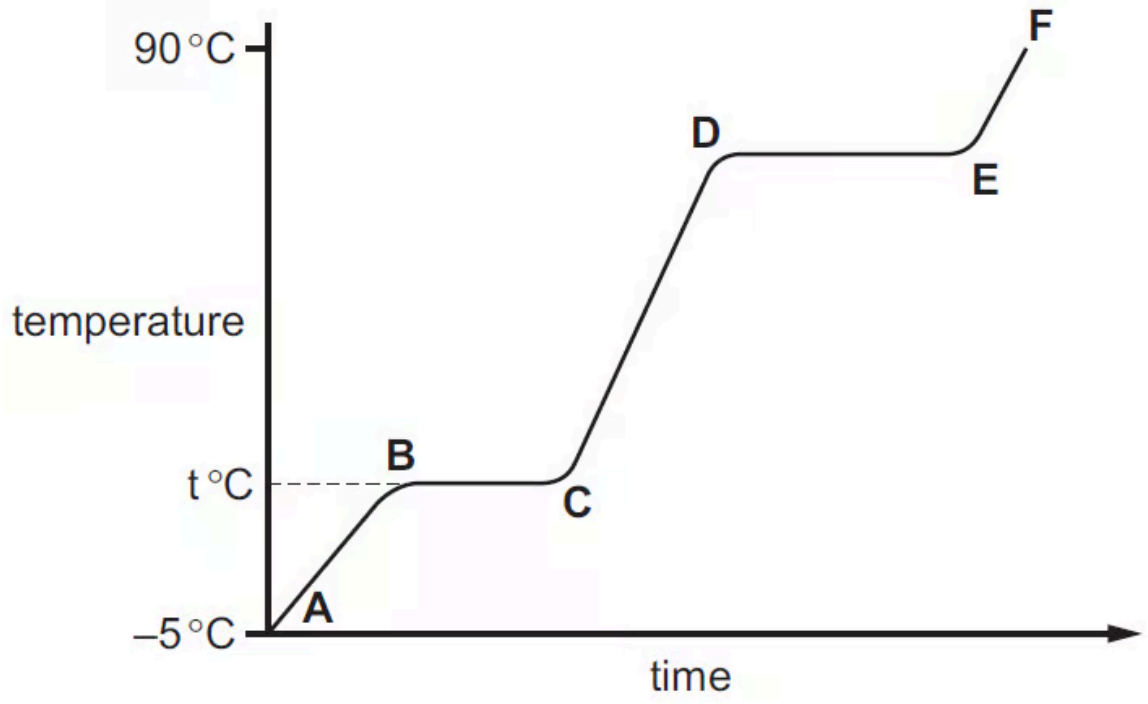
.....

(1 mark)

2 (a) Extended Only

Compound X is a colourless liquid at room temperature.

A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.



i) Complete the equation for the equilibrium present in the region BC.

X (s) ⇌ .....

[1]

ii) What is the significance of temperature t °C?

[1]

iii) What is the physical state of compound X in the region EF?

[1]

iv) What would be the difference in the region BC if an impure sample of X had been used?

[1]

(4 marks)

(b) Separate: Chemistry and Extended Only

Compound X is a hydrocarbon. It contains 85.7% of carbon. The mass of one mole of X is 84 g.

i) What is the percentage of hydrogen in the compound ?

[1]

ii) Calculate the empirical formula of X. Show your working.

[3]

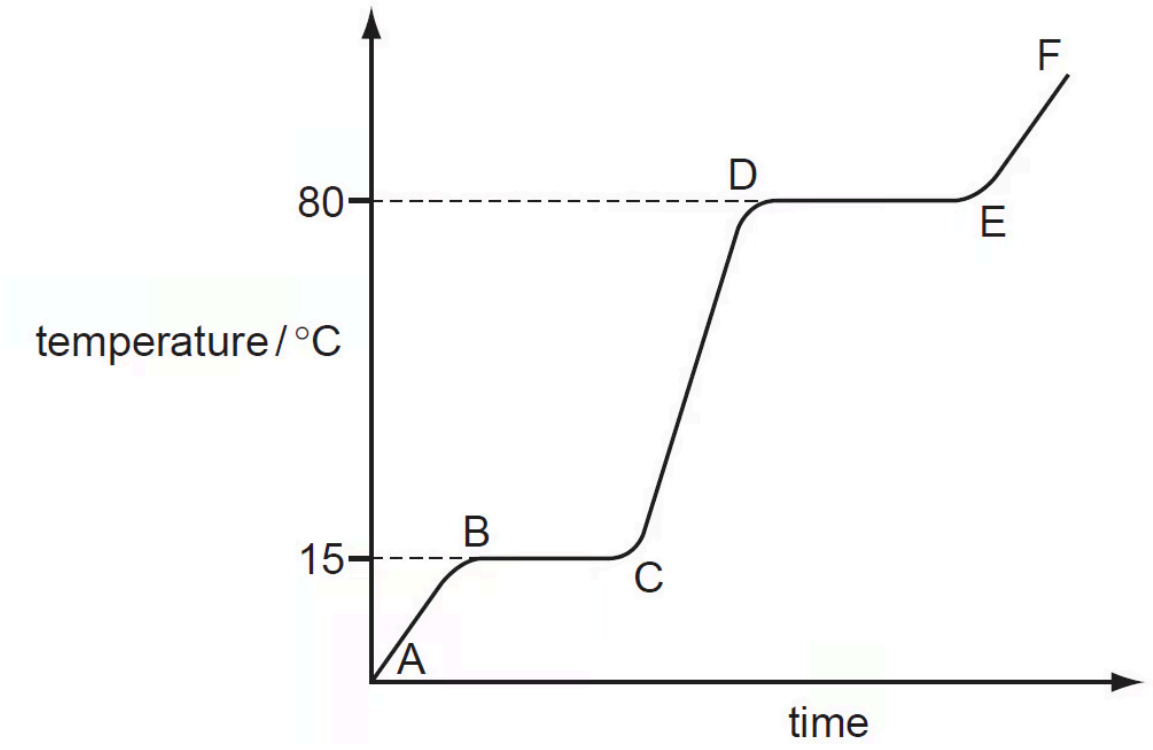
iii) What is the molecular formula of compound X?

[1]

(5 marks)

3 (a) Extended Only

The diagram shows a heating curve for a sample of compound X.



Is X a solid, a liquid or a gas at room temperature, 20 °C?

.....

(1 mark)

(b) Extended Only

Write an equation for the equilibrium which exists in region BC.

.....

(1 mark)

(c) Extended Only

Name the change of state which occurs in region DE.

.....

(1 mark)

(d) Extended Only

Explain how the curve shows that a pure sample of compound X was used.

.....

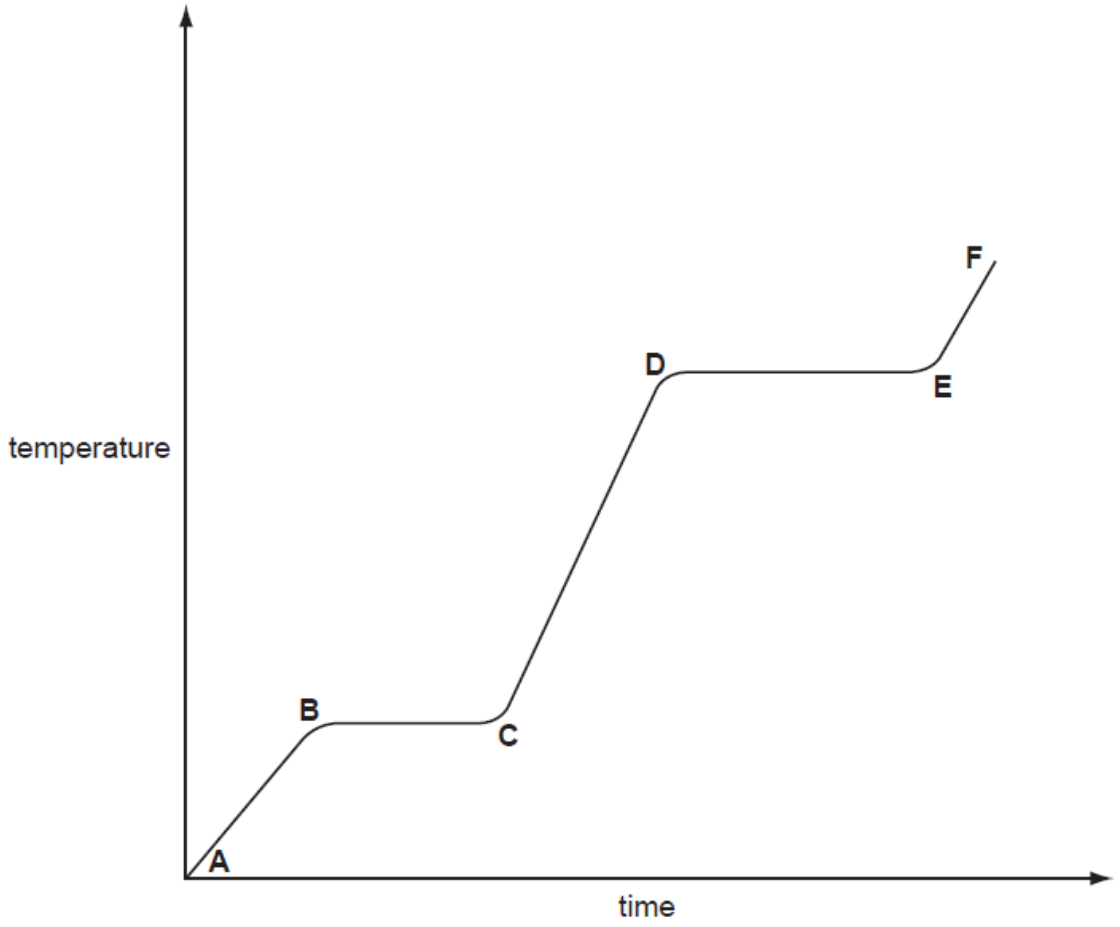
.....

(2 marks)

4 (a) Extended Only

Ethanoic acid is a colourless liquid at room temperature. It has the typical acid properties and forms compounds called ethanoates.

A pure sample of ethanoic acid is slowly heated from 0 ^{o}C to 150 ^{o}C and its temperature is measured every minute. The results are represented on the graph below.



i) Name the change that occurs in the region D to E.

[1]

ii) What would be the difference in the region B to C if an impure sample had been used?

[1]

iii) Sketch on the graph how the line would continue if the acid was heated to a higher temperature.

[1]

iv) Complete the following table that compares the separation and movement of the molecules in regions C to D with those in E to F.

	C to **D**	**E** to **F**
separation (distance between particles)		
movement of particles	random and slow	
Can particles move apart to fill any volume?		

[5]

(8 marks)

(b) Complete the word equations for the reactions of ethanoic acid.

calcium + ethanoic acid → ..... + ...

..... + ethanoic acid → zinc ethanoate + water

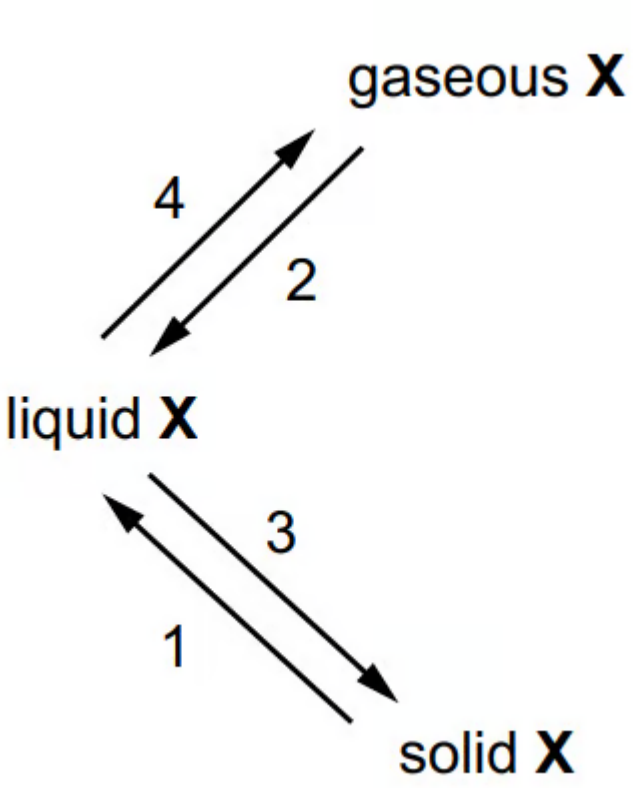
(2 marks)

(c) Write the symbol equation for the reaction between ethanoic acid and sodium hydroxide.

(2 marks)

5 (a) Element X can undergo the following physical changes.

Figure 1.1



Name each of the numbered physical changes shown in **Figure 1**.

.....

.....

.....

.....

(4 marks)

(b) One difference between boiling and evaporation is the rate at which the processes occur.

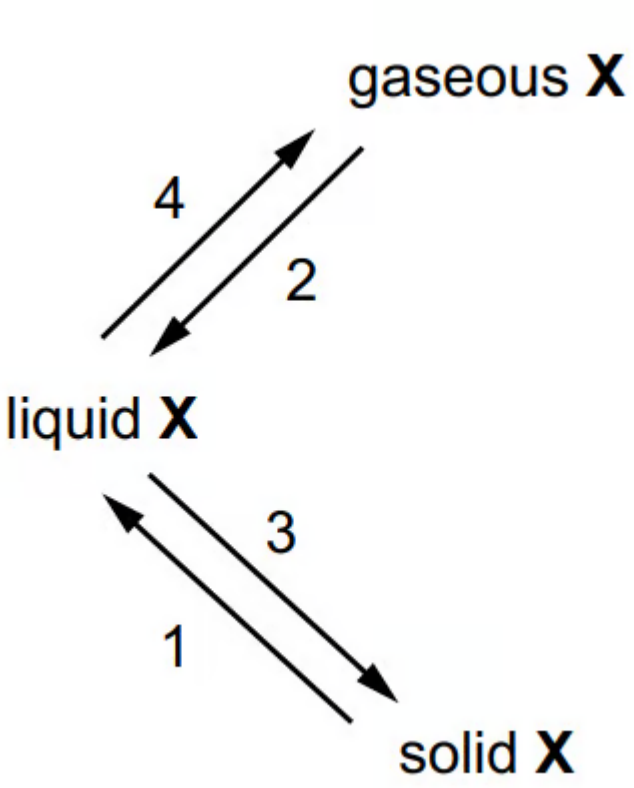
State one other difference between boiling and evaporation.

.....

(1 mark)

(c) Element X can undergo the following physical changes.

Figure 1.1



Describe the separation, arrangement and motion of particles of element X in the solid state.

Separation: .....

Arrangement: .....

Motion: .....

(3 marks)

6 (a) This question is about iodine and compounds of iodine.

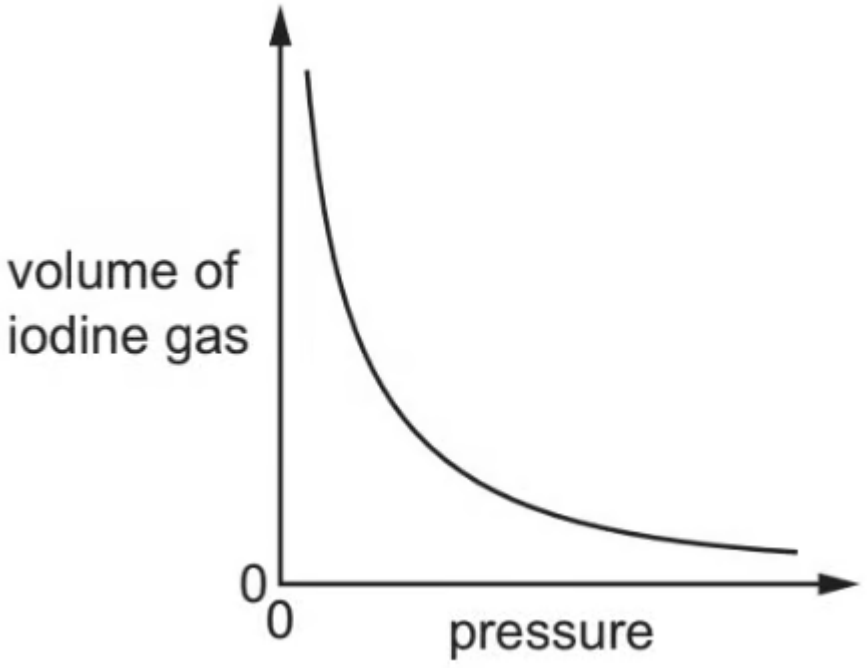
Use the kinetic particle model to describe the separation between the molecules and the type of motion of the molecules in:

Solid iodine:

Iodine gas:

(4 marks)

(b) The graph shows how the volume of iodine gas changes with pressure. The temperature is kept constant.



Describe how the volume of iodine gas changes with pressure.

(1 mark)

(c) Sulfur dioxide melts at –73 °C and boils at –10 °C.

What is the physical state of sulfur dioxide at –20 °C?

Explain your answer.

.....

.....

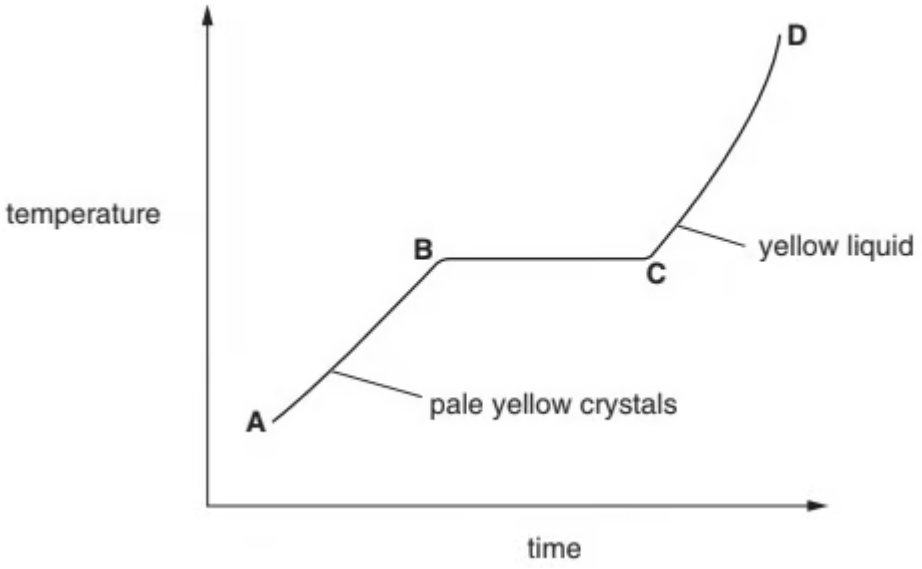
(2 marks)

Hard Questions

1 (a) Nitrogen dioxide, NO_2, is a dark brown gas.

When nitrogen dioxide is cooled, it forms a yellow liquid and then pale yellow crystals.

These crystals are heated and the temperature is measured every minute. The following graph can be drawn.



i) Describe the arrangement and movement of the molecules in the region A–B.

[3]

ii) Name the change that occurs in the region B–C.

[1]

(4 marks)

(b) Extended Only

Nitrogen dioxide and other oxides of nitrogen are formed in car engines.

i) Explain how these oxides are formed.

[2]

ii) How are they removed from the exhaust gases?

[2]

.....

.....

.....

.....

(4 marks)

(c) Extended Only

Nitrogen dioxide, oxygen and water react to form dilute nitric acid.

Describe how lead(II) nitrate crystals could be prepared from dilute nitric acid and lead(II) oxide.

.....

.....

.....

(3 marks)

2 (a) A small amount of liquid bromine is added to a container which is then sealed.

$$Br_2(l) \rightarrow Br_2(g)$$

Use the ideas of the Kinetic Theory to explain why, after about an hour, the bromine molecules have spread uniformly to occupy the whole container.

.....

.....

.....

(3 marks)

(b) Extended Only

The diagrams below show simple experiments on the speed of diffusion of gases.

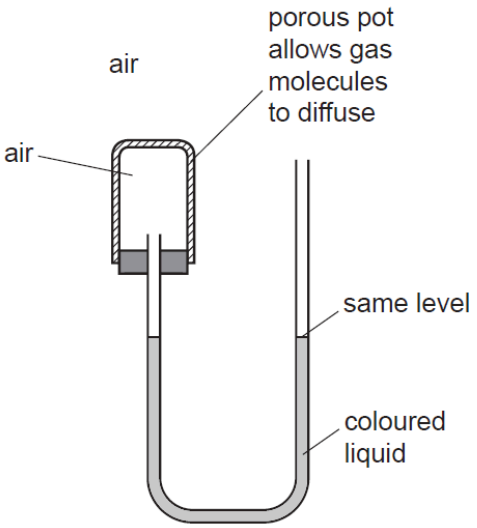


diagram 1

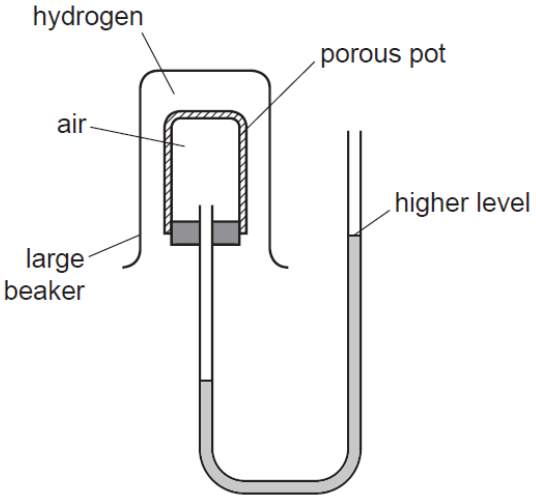


diagram 2

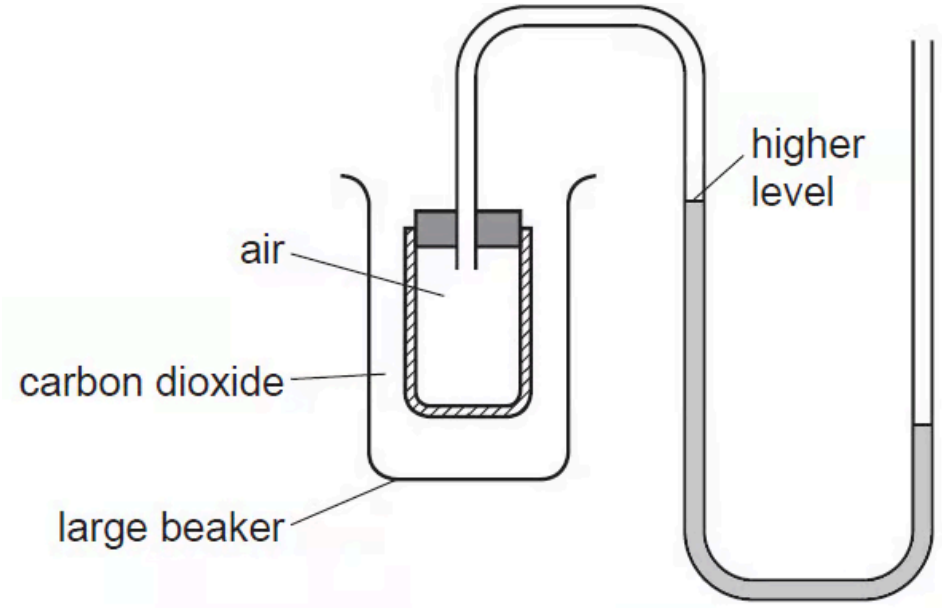


diagram 3

Complete the following explanations. Diagram 1 has been done for you.

Diagram 1 There is air inside and outside the porous pot so the rate of diffusion of air into the pot is the same as the rate of diffusion of air out of the pot. The pressure inside and outside the pot is the same so the coloured liquid is at the same level on each side of the tube.

Diagram 2.

.....

Diagram 3

.....

(6 marks)

3 (a) Separate: Chemistry and Extended Only

Acid-base reactions are examples of proton transfer.

Ethylamine is a weak base and sodium hydroxide is a strong base.

i) In terms of proton transfer, explain what is meant by the term *weak base*.

[2]

ii) Given aqueous solutions of both bases, describe how you could show that sodium hydroxide is the stronger base. How could you ensure a 'fair' comparison between the two solutions?

[3]

(5 marks)

(b) Ethylamine reacts with acids to form salts.

$$CH_3CH_2NH_2 \quad + \quad HCl \quad \rightarrow \quad CH_3CH_2NH_3Cl$$

ethylammonium chloride

i) Complete the equation for the reaction between sulfuric acid and ethylamine. Name the salt formed.

..... $CH_3CH_2NH_2$ + ... → .....

Name of salt .....

[3]

ii) Amines and their salts have similar chemical properties to ammonia and ammonium salts.

Suggest a reagent that could be used to displace the weak base, ethylamine, from its salt ethylammonium chloride.

[1]

.....

.....

.....

.....

(4 marks)

(c) Extended Only

Gases diffuse, which means that they move to occupy the total available volume.

i) Explain, using kinetic particle theory, why gases diffuse.

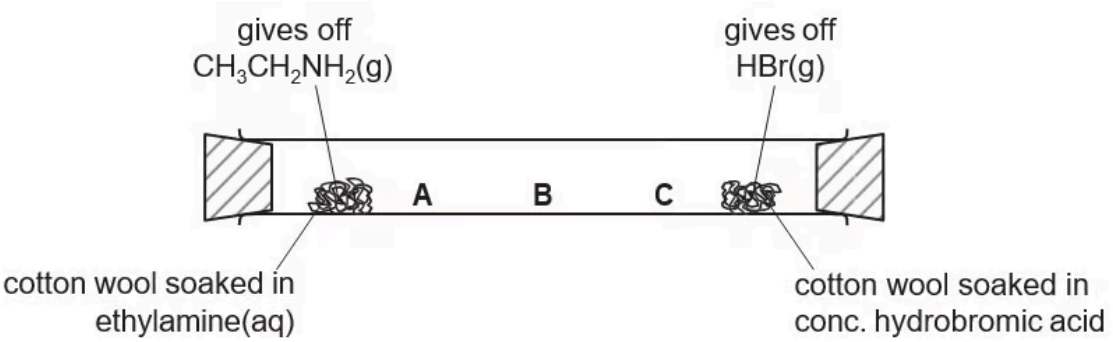
[2]

ii) When the colourless gases hydrogen bromide and ethylamine come into contact, a white solid is formed.

$$CH_3CH_2NH_2\,(g) + HBr\,(g) \rightarrow CH_3CH_2NH_3Br\,(s)$$

white solid

The following apparatus can be used to compare the rates of diffusion of the two gases ethylamine and hydrogen bromide.



Predict at which position, A, B or C, the white solid will form. Explain your choice.

[3]

(5 marks)

4 (a) Extended Only

Different gases diffuse at different speeds.

i) What is meant by the term *diffusion*?

[1]

ii) What property of a gas molecule affects the speed at which it diffuses?

[1]

.....

.....

(2 marks)

(b) Extended Only

Helium is a gas used to fill balloons. It is present in the air in very small quantities. Diffusion can be used to separate it from the air. Air at 1000°C is on one side of a porous barrier. The air which passes through the barrier has a larger amount of helium in it.

i) Why does the air on the other side of the barrier contain more helium?

[1]

ii) Why is it an advantage to have the air at a high temperature?

[1]

.....

.....

(2 marks)

(c) Most helium is obtained from natural gas found in the USA. Natural gas contains methane and 7% helium. One possible way to obtain the helium would be to burn the methane.

i) Write an equation for the complete combustion of methane.

[1]

ii) Suggest why this would not be a suitable method to obtain the helium.

[1]

iii) Suggest another method, other than diffusion, by which helium could be separated from the mixture of gases in natural gas.

[1]

.....

.....

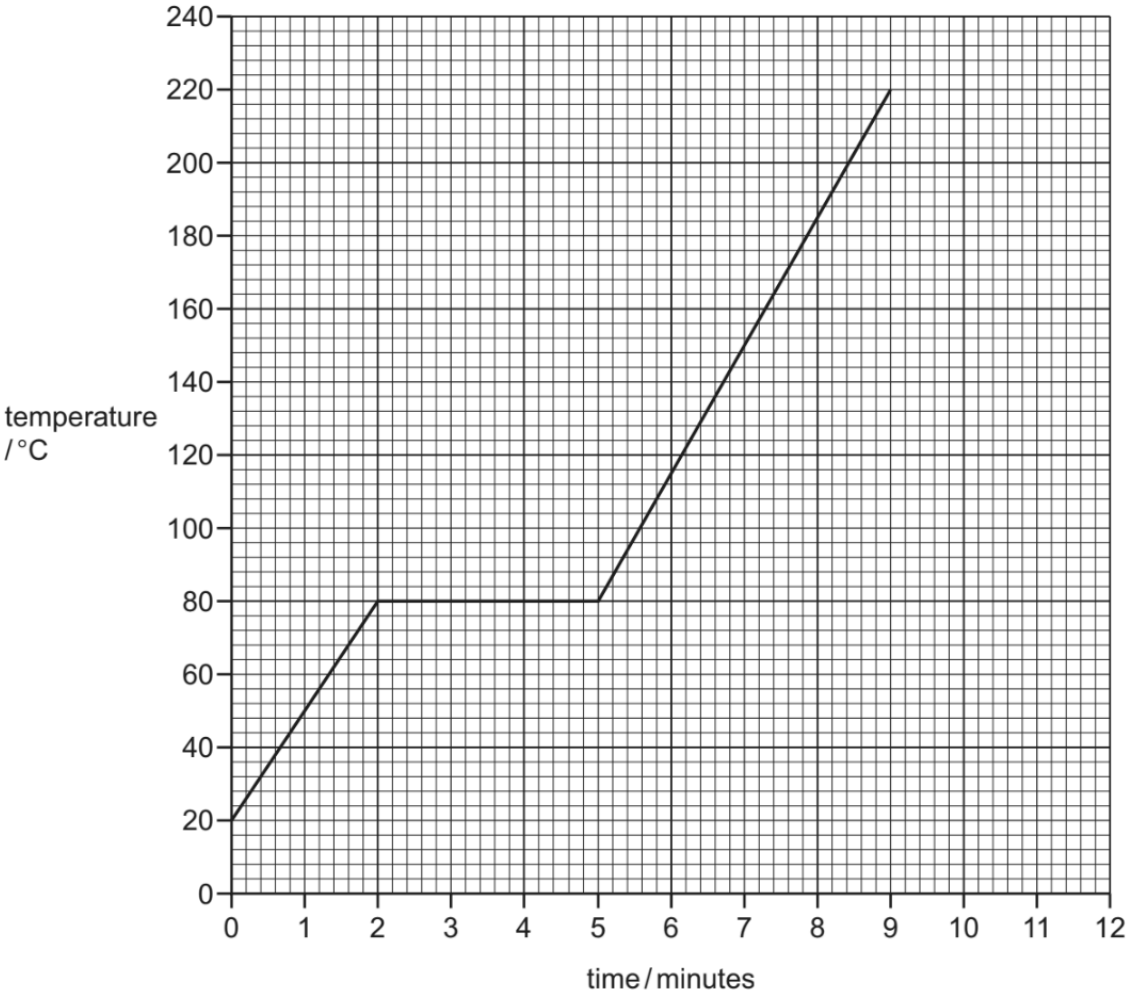
.....

(3 marks)

5 (a) Extended Only

Z is a covalent substance. In an experiment, a sample of pure solid Z was continually heated for 12 minutes.

The graph shows how the temperature of the sample of pure Z changed during the first 9 minutes.



What is the melting point of pure Z?

.....

(1 mark)

(b) Extended Only

The sample of pure Z began to boil at 9 minutes. It was boiled for 3 minutes. Use this information to sketch on the grid, in part (a), how the temperature of the sample of pure Z changed after 9 minutes.

(1 mark)

(c) Extended Only

The sample of pure Z was continually heated between 2 minutes and 5 minutes.

Explain, in terms of attractive forces, why there was no increase in the temperature of the sample of pure Z between 2 minutes and 5 minutes.

(2 marks)

(d) Extended Only

Describe how the motion of particles of pure Z changed from 0 minutes to 2 minutes.

(2 marks)

(e) The experiment was repeated using a solid sample of impure Z.

Suggest the differences, if any, in the melting point and boiling point of the sample of impure Z compared to the sample of pure Z.

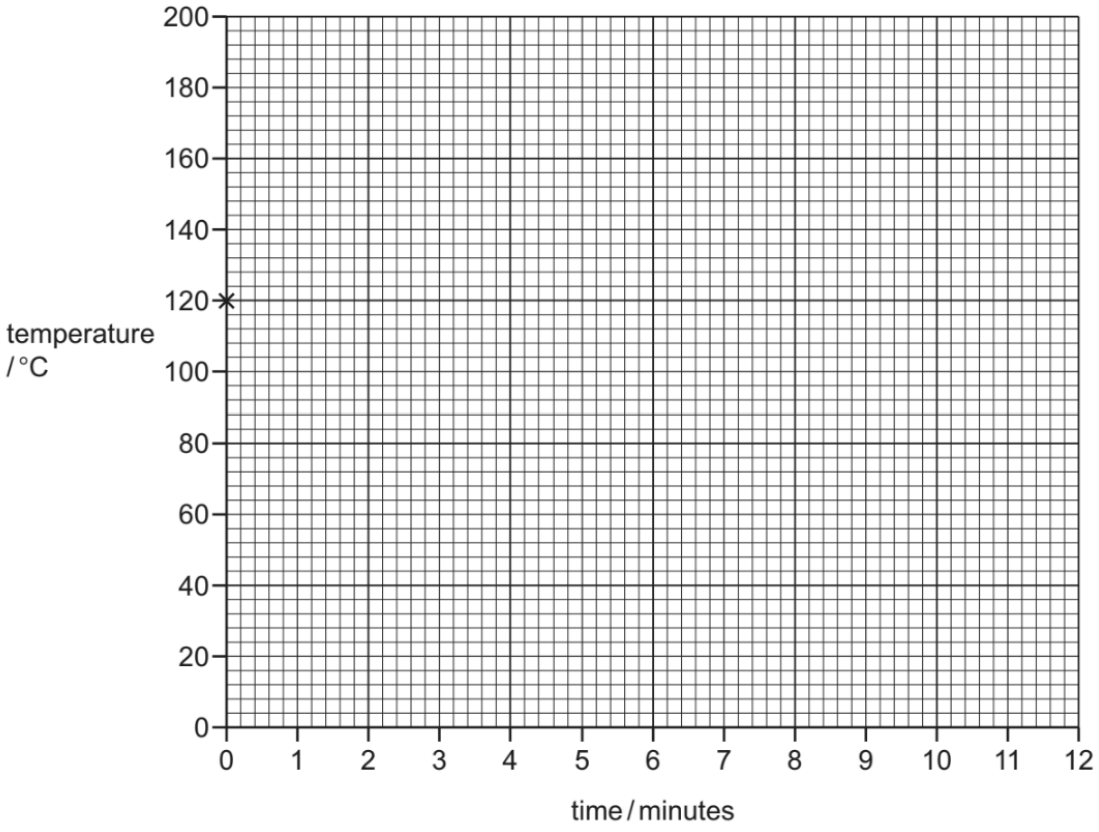
melting point:

boiling point:

(2 marks)

(f) Extended Only

A sample of pure Z was allowed to cool from 120 °C to 20 °C. The total time taken was 8 minutes.



Starting from point ×, sketch on the grid how the temperature of the sample of pure Z changed between 0 minutes and 8 minutes.

(2 marks)

6 (a) Extended Only

Kinetic theory explains the properties of matter in terms of the arrangement and movement of particles.

Nitrogen is a gas at room temperature. Nitrogen molecules, N_2, are spread far apart and move in a random manner at high speed.

i) Draw the electronic structure of a nitrogen molecule. Show only the outer electron shells.

[2]

ii) Compare the movement and arrangement of the molecules in solid nitrogen to those in nitrogen gas.

[3]

(5 marks)

(b) Extended Only

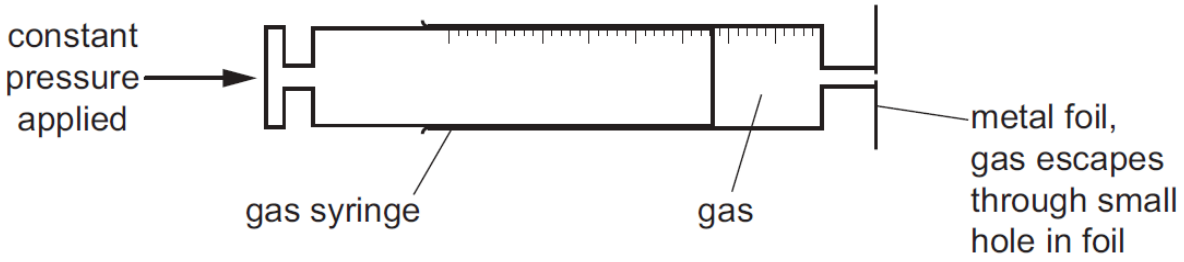
A sealed container contains nitrogen gas. The pressure of the gas is due to the molecules of the gas hitting the walls of the container.

Use the kinetic theory to explain why the pressure inside the container increases when the temperature is increased.

(2 marks)

(c) Extended Only

The following apparatus can be used to measure the rate of diffusion of a gas.



The following results were obtained.

gas	temperature/ ^{o}C	rate of diffusion in cm^3 / min
nitrogen	25	1.00
chlorine	25	0.63
nitrogen	50	1.05

i) Explain why nitrogen gas diffuses faster than chlorine gas.

[2]

ii) Explain why the nitrogen gas diffuses faster at the higher temperature.

[1]

.....

.....

.....

(3 marks)