Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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States of matter

Time allowed: 1 hour 20 minutes

Subject code **0620**

Chemistry

Questions from Paper 3 and Paper 4

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 84

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 84 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

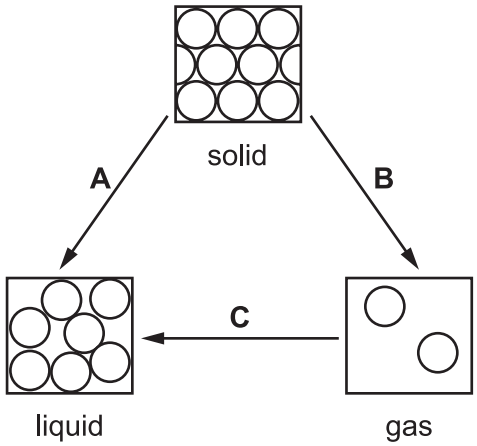
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Matter can exist as solid, liquid or gas. The arrows show some changes of state.



(a) Name the changes of state represented on the diagram.

(i) **A** ..... [1]

(ii) **B** ..... [1]

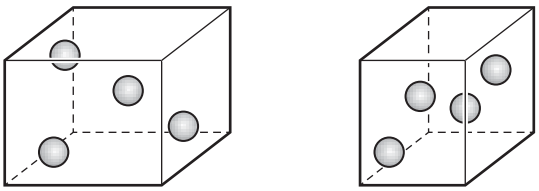
(iii) **C** ..... [1]

(b) Explain why energy has to be supplied to turn a liquid into a gas.

.....

..... [1]

(c) The diagrams represent the same number of particles of a gas in two containers, **D** and **E**, which have different volumes. The two containers are at the same temperature.



In which container will the pressure be higher? Explain your answer.

.....

.....

..... [1]

[Total: 5]

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Solids, liquids, gases and changes of state Click for more variations

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1(a)(i)	melt(ing)	**1**
1(a)(ii)	sublimation / sublime	**1**
1(a)(iii)	condensing / condensation	**1**
1(b)	overcome / break the attractive forces	**1**
1(c)	**E AND** particles hit the walls (of the container) more often	**1**

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2 The symbol for an atom of krypton is shown.

$$^{84}_{36}Kr$$

(a) Complete Table 2.1 to show the number of electrons and neutrons in one atom of $^{84}_{36}Kr$.

Table 2.1

number of electrons	
number of neutrons	

[2]

(b) Krypton is a gas at room temperature and pressure.

A sample of krypton is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of krypton when:

- the temperature of the krypton is decreased
- the pressure of the krypton is increased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of krypton
temperature is decreased	
pressure is increased	

[2]

(c) When krypton is cooled, it becomes a liquid.

Describe the arrangement of the particles in liquid krypton.
Give your answer in terms of particle separation and motion.

particle separation .....

.....

particle motion .....

.....

[2]

[Total: 6]

STEM | Exam Builder

Protons, neutrons, electrons and electronic configuration Click for more variations

2(a) **2**

number of electrons	36
number of neutrons	48

2(b) **2**

change	effect on the volume of krypton
temperature is decreased	decreases
pressure is increased	decreases

2(c) **2**

separation: close together / touching / packed / not separated (1)

motion: sliding over each other / random (1)

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3 Bromine is a liquid at room temperature.

(a) State **two** general properties of a liquid.

1 .....

.....

2 .....

.....

[2]

(b) Fig. 4.1 shows the physical states of bromine.

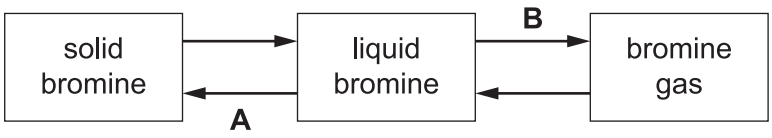


Fig. 4.1

Name the changes of physical states **A** and **B**.

A .....

B .....

[2]

(c) Describe liquid bromine and bromine gas in terms of the arrangement and motion of the particles.

liquid bromine

arrangement .....

.....

motion .....

.....

bromine gas

arrangement .....

.....

motion .....

.....

[4]

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(d) A sealed gas syringe contains 80 cm^3 of bromine gas.

State how decreasing the pressure affects the volume of bromine gas in the gas syringe when the temperature remains constant.

..... [1]

[Total: 9]

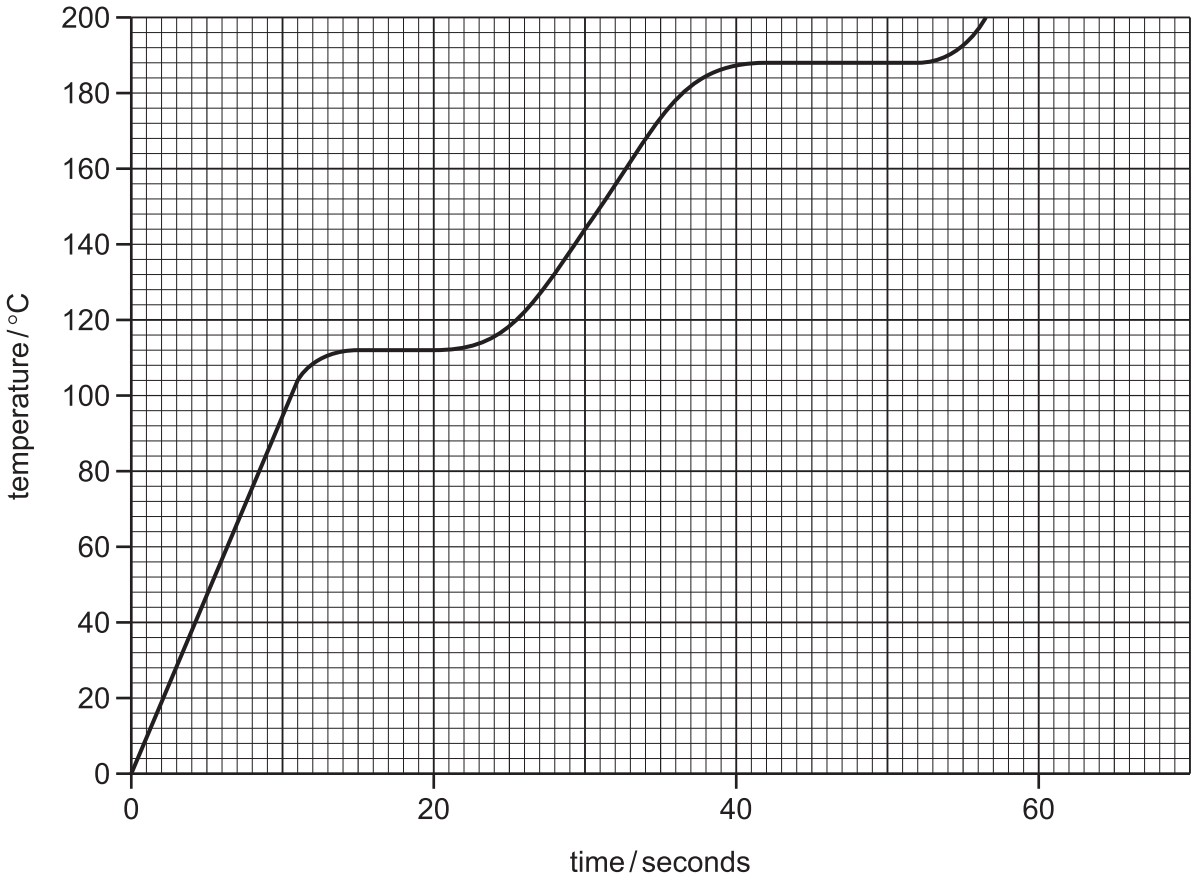
Solids, liquids, gases and changes of state Click for more variations

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3(a)	1 mark each for any two of: • has a definite volume / fixed volume • takes the shape of its container • flows over a surface / can be poured over a surface	**2**
3(b)	A: freezing (1) B: evaporation / boiling (1)	**2**
3(c)	liquid bromine: arrangement: irregular / no (particular) arrangement (1) motion: sliding / moving (over each other) (1) bromine gas: arrangement: irregular / no (particular) arrangement (1) motion: fast / rapid / move everywhere (1)	**4**
3(d)	volume increases	**1**

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4 The graph below shows how the temperature rises with time when a solid, **P**, is heated steadily and changes to a liquid and then to a gas.



(a) Use the information on the graph to deduce

the melting point of **P**, ...

the state of **P** at 160 °C. ..... [2]

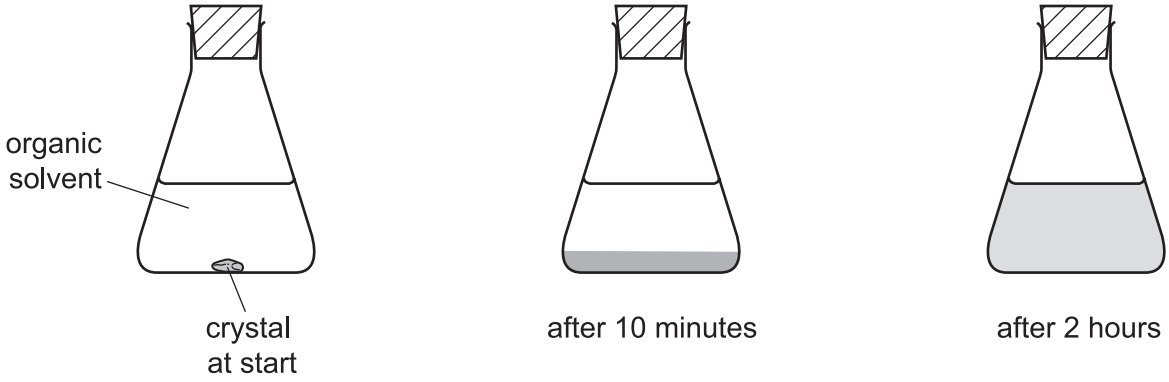
(b) Explain what happens to the arrangement and motion of the particles when a solid changes to a liquid.

arrangement .....

motion ..... [2]

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(c) A student placed a purple crystal in a flask of organic solvent.
After 10 minutes, the crystal had completely disappeared and a dense purple colour was observed at the bottom of the flask.
After 2 hours, the purple colour had spread throughout the solvent.



Use the kinetic particle theory to explain these observations.

.....

.....

.....

..... [3]

[Total: 7]

Diffusion Click for more variations

4 **(a)** 112 (°C) [1]

liquid [1]

(b) arrangement: go from regularly to irregularly arranged / become more irregularly arranged / go from regular to random [1]
ALLOW: idea of becoming less packed / less arranged / not so close together (but not implication of particles being apart from each other)
NOTE: do not allow implication of particles being 'apart' in solid
motion: start moving / start sliding over each other / go from no movement to movement / go from just vibrating to moving (over each other) [1]
ALLOW: idea of greater movement

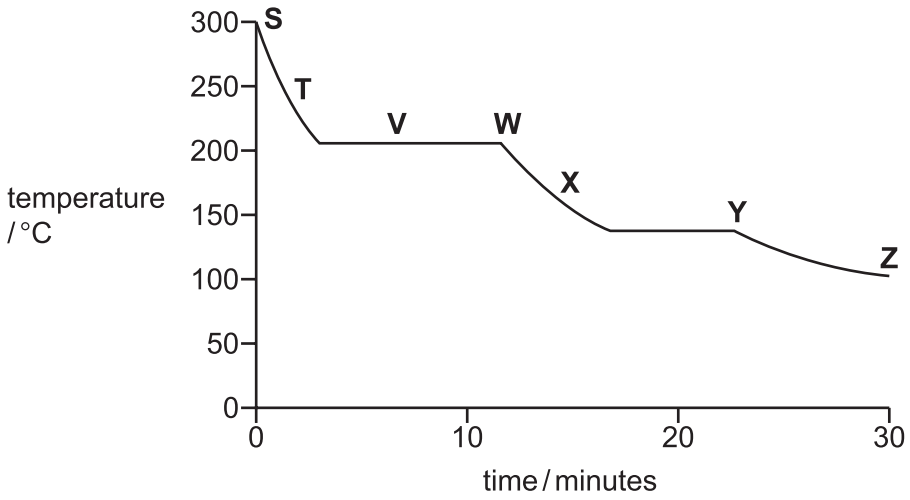
(c) Any three of: [3]

(crystal) dissolves / idea of dissolving
particles (in crystal) become separated / solvent molecules get in between particles / mixing of particles / spreading out of particles
diffusion
movement of particles (in solution)
random (movement of particles)
particles collide
ALLOW: particles move from concentrated to dilute solution

[Total: 7]

STEM | Exam Builder

5 The graph shows how the temperature of a substance changes as it is cooled over a period of 30 minutes. The substance is a gas at the start.



Each letter on the graph may be used once, more than once or not at all.

(a) Which letter, **S**, **T**, **V**, **W**, **X**, **Y** or **Z**, shows when

(i) the particles in the substance have the most kinetic energy,

..... [1]

(ii) the particles in the substance are furthest apart,

..... [1]

(iii) the substance exists as both a gas and a liquid?

..... [1]

(b) Use the graph to estimate the freezing point of the substance.

..... °C [1]

(c) Name the change of state directly from a solid to a gas.

..... [1]

(d) When smoke is viewed through a microscope, the smoke particles in the air appear to jump around.

(i) What term describes this movement of the smoke particles?

..... [1]

(ii) Explain why the smoke particles move in this way.

.....

.....

..... [2]

[Total: 8]

Diffusion Click for more variations

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5(a)(i)	**S**	**1**
5(a)(ii)	**S**	**1**
5(a)(iii)	**V**	**1**
5(b)	any value in the range 130–145 °C	**1**
5(c)	sublimation	**1**
5(d)(i)	Brownian motion	**1**
5(d)(ii)	nitrogen / oxygen / carbon dioxide / air molecules hit / bombard the smoke particles	**1**
	(the bombarding particles) move randomly	**1**

6 This question is about states of matter.

(a) Complete the table, using ticks (✓) and crosses (✗), to describe the properties of gases, liquids and solids.

state of matter	particles are touching	particles have random movement	particles are regularly arranged
gas			
liquid			
solid			

[3]

(b) Substances can change state.

(i) Boiling and evaporation are two ways in which a liquid changes into a gas.

Describe **two** differences between boiling and evaporation.

1 .....

2 .....

[2]

(ii) Name the change of state when:

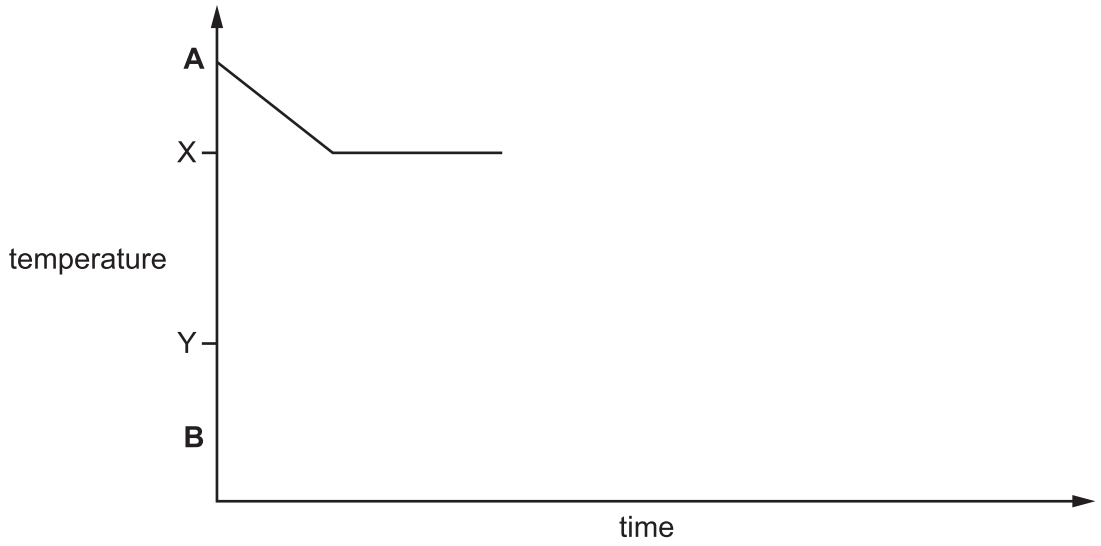
- a gas becomes a liquid .....
- a solid becomes a gas. .....

[2]

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(c) A substance boils at temperature X and melts at temperature Y.

Complete the graph to show the change in temperature over time as the substance cools from temperature **A** to temperature **B**.



[2]

(d) A solution is a mixture of a solute and a solvent.

(i) Name the process when a solid substance mixes with a solvent to form a solution.

..... [1]

(ii) Name the type of reaction when two solutions react to form an insoluble substance.

..... [1]

[Total: 11]

Solids, liquids, gases and changes of state Click for more variations

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6(a)	1 mark for each correct row State / touching / random movement / regularly arranged Gas / / ✔ / Liquid / ✔ / ✔ / Solid / ✔ / / ✔	**3**
6(b)(i)	boiling happens at a specific temperature (1) boiling has bubbles (1)	**2**
6(b)(ii)	condensation (1) sublimation (1)	**2**
6(c)	one horizontal line level with Y (1) two separate decreases before and after horizontal line (1)	**2**
6(d)(i)	dissolving	**1**
6(d)(ii)	precipitation	**1**

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7 **(a)** Dust particles in the air move around in a random way.

(i) What term describes the random movement of the dust particles?

..... [1]

(ii) Identify the particles in the air which cause the random movement of the dust particles.

..... [2]

(iii) Explain why the dust particles move in this way.

.....

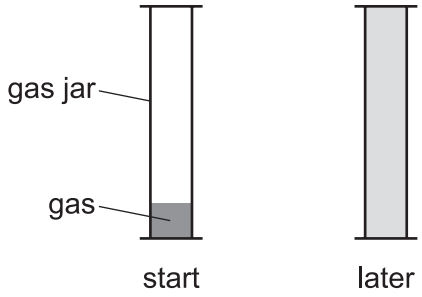
.....

..... [2]

(b) When chlorine gas, Cl_2, is put into a gas jar, it spreads out to fill the gas jar.

When bromine gas, Br_2, is put into a gas jar, it also spreads out to fill the gas jar.

The process takes longer for bromine gas than for chlorine gas.



(i) What term describes the way that the gas particles spread out?

..... [1]

(ii) Use **data** from the Periodic Table to explain why bromine gas takes longer to fill a gas jar than chlorine gas.

.....

.....

..... [2]

(iii) Explain why increasing the temperature increases the rate at which the gas particles spread out.

.....

..... [1]

[Total: 9]

Diffusion Click for more variations

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7(a)(i)	Brownian (motion)	1
7(a)(ii)	molecules	1
	nitrogen / N_2 / N **OR** oxygen / O_2 / O	1
7(a)(iii)	nitrogen **OR** oxygen (particles) collide with / bombard / hit the dust (particles)	1
	(the bombarding particles) move **randomly**	1
7(b)(i)	diffusion	1
7(b)(ii)	Br_2 has an M_r of 160 **AND** Cl_2 has an M_r of 71 / bromine has an A_r of 80 **AND** chlorine has an A_r of 35.5	1
	(heavier) bromine (molecules / particles) diffuses more slowly	1
7(b)(iii)	particles have more energy / move faster	1

8 The Kinetic Theory explains the properties of matter in terms of the arrangement and movement of particles.

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

(i) Draw a diagram showing the arrangement of the valency electrons in a nitrogen molecule.
Use × to represent an electron from a nitrogen atom.

[2]

(ii) How does the movement and arrangement of the molecules in a crystal of nitrogen differ from those in gaseous nitrogen?

.....

.....

..... [3]

(b) Use the ideas of the Kinetic Theory to explain the following.

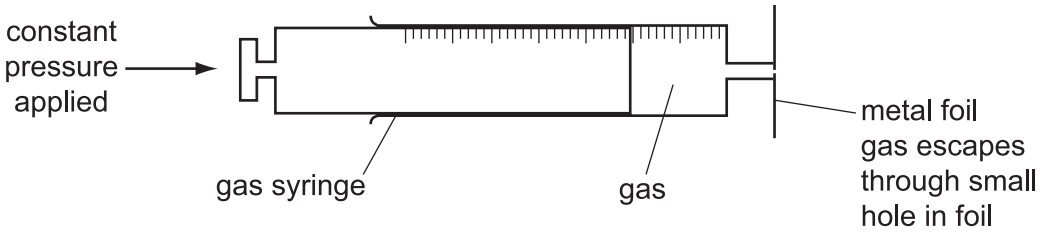
(i) A sealed container contains nitrogen gas. The pressure of a gas is due to the molecules of the gas hitting the walls of the container.
Explain why the pressure inside the container increases when the temperature is increased.

.....

..... [2]

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



The following results were obtained.

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

Explain why nitrogen diffuses faster than chlorine.

.....

..... [2]

Explain why the nitrogen diffuses faster at the higher temperature.

..... [1]

[Total: 10]

Solids, liquids, gases and changes of state Click for more variations

8 **(a)** **(i)** 6e between two nitrogen atoms (can be any combination of dots or crosses) [1]
1 lone pair on each nitrogen atom [1]

(ii)

	SOLID	GAS	
PATTERN	regular / lattice (**not** fixed)	random / irregular / no pattern	[1]
DISTANCE	close	far apart / spread out	[1]
MOVEMENT	vibrate / fixed / no motion	moving / translational	[1]

(b) **(i)** **particles/molecules** have more energy / move faster [1]
collide harder / collide more frequently / more collisions / collide with more force (with the walls) [1]

(ii) (1) nitrogen has small**er** M_r / light**er** molecules / low**er** density [1]
nitrogen **molecules** / **particles** **move** fast**er** (than chlorine molecules) [1]

(2) at higher temperature nitrogen **molecules or particles** (not atoms) move faster / have more energy [1]

[Total: 10]

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9 **(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]

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

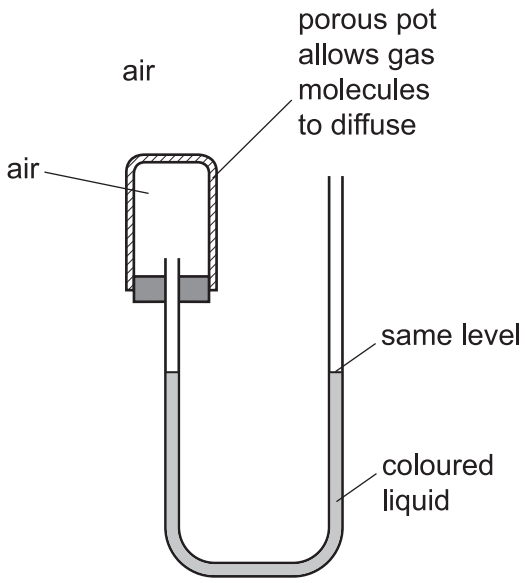


diagram 1

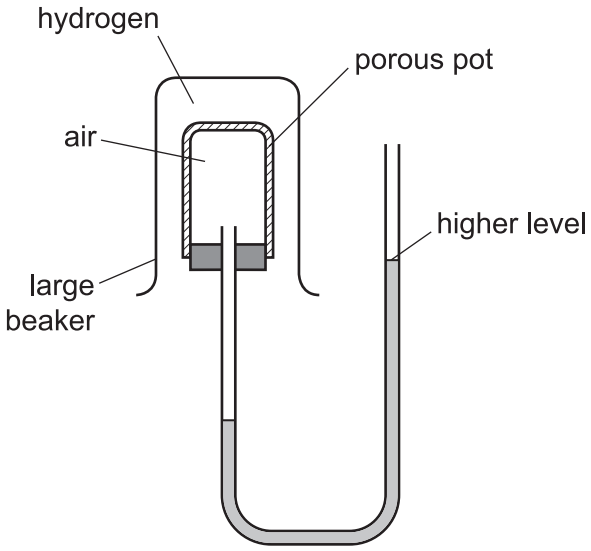


diagram 2

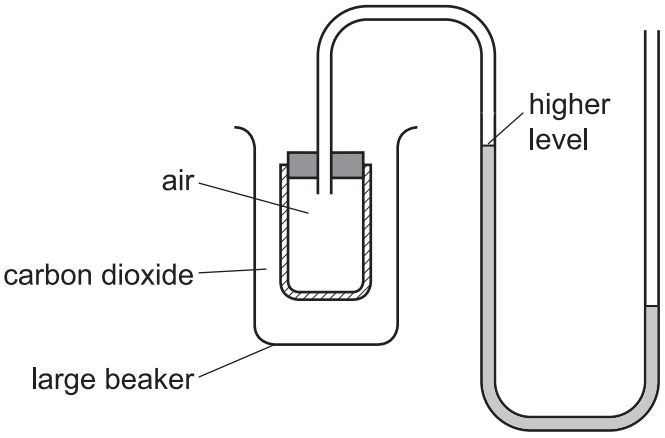


diagram 3

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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

.....

.....

.....

..... [3]

Diagram 3

.....

.....

.....

..... [3]

[Total: 9]

Diffusion Click for more variations

9 **(a)** explanation of evaporation e.g. particles (or molecules) with a lot of energy leave the liquid / bromine particles break free from each other / forces or bonds between bromine molecules broken / molecules (in liquid) have weak forces holding them together / weak intermolecular forces / Van der Waals forces between molecules (don't have to be stated as weak) / (weak intermolecular forces alone scores this mark);
allow: particles (or molecules) of bromine escape from liquid [1]

diffusion / diffuse / movement of particles; [1]

explanation of diffusion involving qualified movement of molecules / particles
i.e. random movement of molecules / particles move in all directions; [1]

(b) air more dense / heavier / higher M_r than hydrogen; [1]
hydrogen diffuses faster (than air diffuses out); [1]
accept: diffusion in is faster than out (without naming gases)
pressure inside pot is greater (than outside); [1]
air less dense / lighter / lower M_r than carbon dioxide; [1]

air diffuses / moves faster (than carbon dioxide); [1]
accept: diffusion out is faster than in (without naming gases)

pressure inside pot less (than outside); [1]

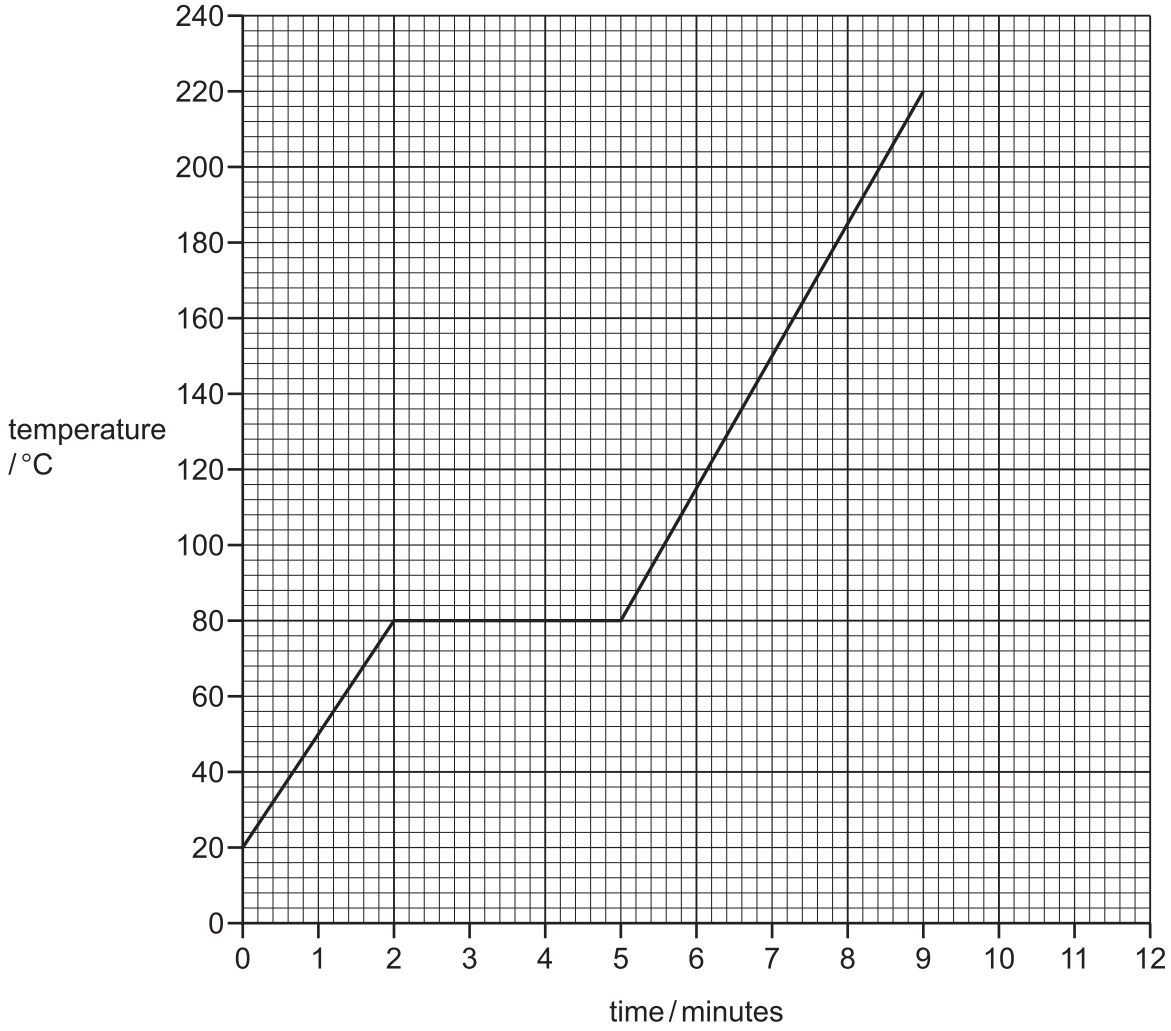
ORA in both parts

[Total: 9]

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10 **Z** is a covalent substance. In an experiment, a sample of pure solid **Z** was continually heated for 11 minutes.

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



(a) What is the melting point of pure **Z**?

..... °C [1]

(b) The sample of pure **Z** began to boil at 9 minutes. It was boiled for 2 minutes.

Use this information to sketch on the grid how the temperature of the sample of pure **Z** changed between 9 minutes and 11 minutes. [1]

(c) 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]

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(d) Describe how the motion of particles of pure **Z** changed from 0 minutes to 2 minutes.

.....

..... [2]

(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**.

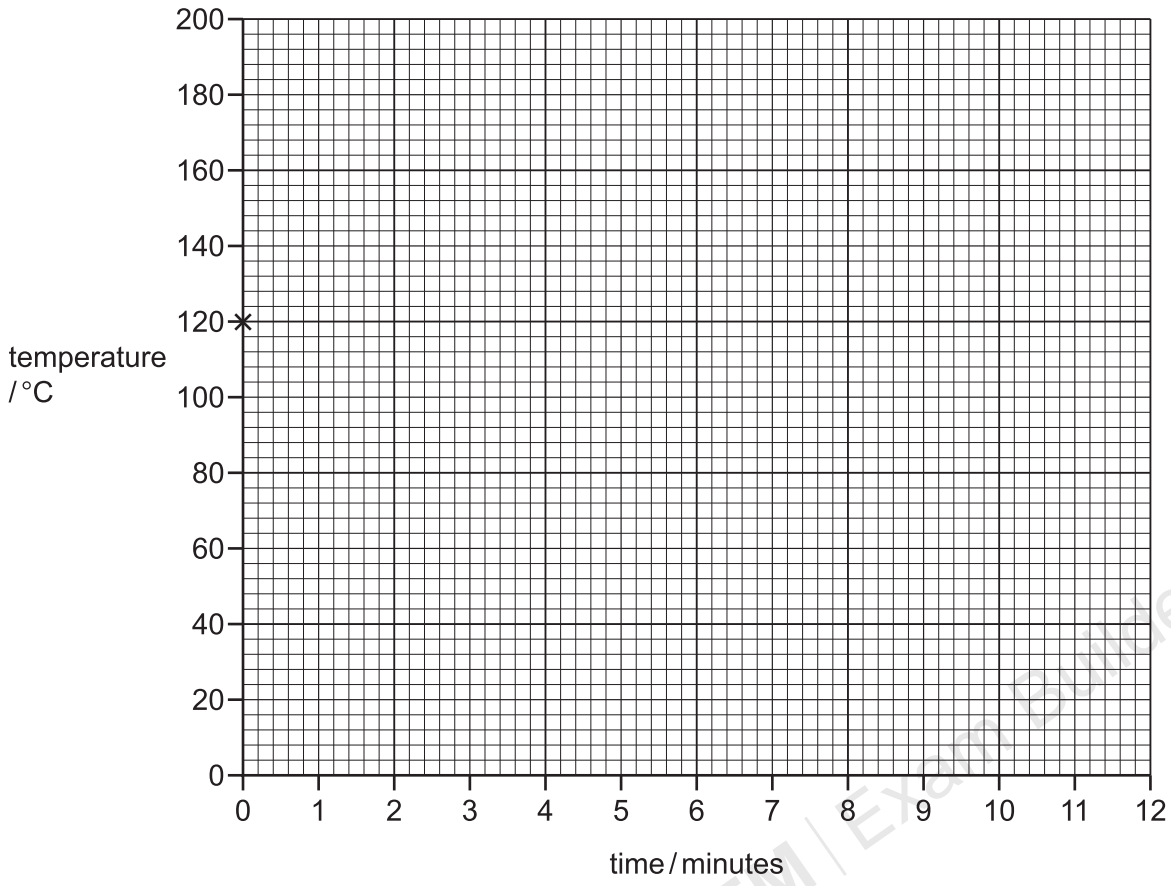
melting point .....

boiling point .....

[2]

(f) 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]

[Total: 10]

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Solids, liquids, gases and changes of state Click for more variations

10(a)	80(°C) (1)	**1**
10(b)	horizontal line from end of graph at minute 9 to minute 11 (1)	**1**
10(c)	energy is used to break bonds / overcome attraction (1) between molecules (1)	**2**
10(d)	vibrations (1) increase (1)	**2**
10(e)	melting point decreases (1) boiling point increases (1)	**2**
10(f)	decrease from 120 °C to 80 °C and horizontal line at 80 °C (1) decrease from horizontal line to finish at 20 °C at 8 mins (1)	**2**

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