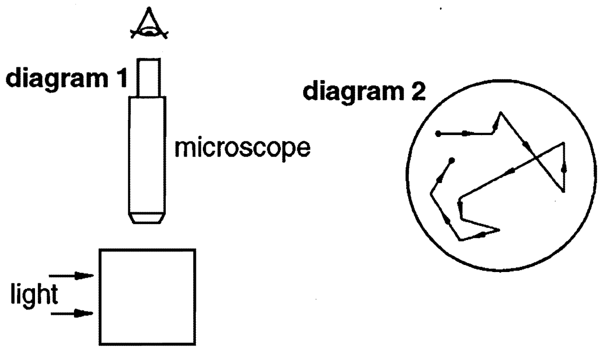
TOPIC 8 Kinetic Model of Matter

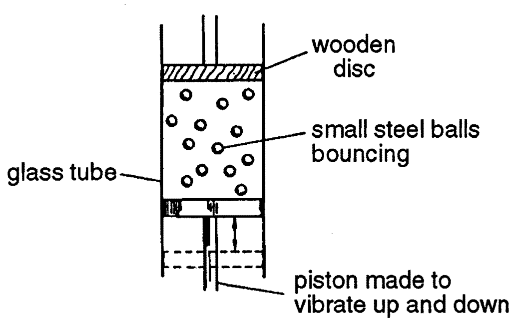
1 Diagram 1 shows smoke particles in a transparent box observed using a microscope. Small points of light are seen to move around as shown in diagram 2.



What does this experiment demonstrate about air molecules?

A They are in continuous random motion.
B They can be seen through a microscope.
C They move more quickly when they are heated.
D They move because of collisions with smoke particles.
E They give out light when they collide with smoke particles. J90/I/10

2 The diagram shows a model to demonstrate the behaviour of gas molecules.

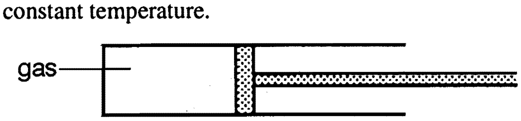


When the piston is vibrated more rapidly, the wooden disc is forced further up the tube. Weights have to be placed on the disc to return it to its original position.

The model represents what happens to a gas when it is

A cooled then compressed.
B cooled then heated.
C heated then compressed.
D heated then cooled.
E expanded then cooled. N90/I/16

3 The volume of a constant mass of gas in a cylinder is reduced at constant temperature.



The pressure exerted by the molecules of the gas increases because

A the gas molecules speed up.
B the density of the gas increases.
C the gas molecules collide with each other more often.
D the gas molecules strike the cylinder walls more often.
E there is a smaller area of cylinder in contact with the gas. J91/I/12

4 A student observes the Brownian motion of smoke particles in air with a microscope. She sees moving points of light.

These points of light come from

A air particles only moving randomly.
B air particles only vibrating.
C smoke particles only moving randomly.
D smoke particles only vibrating.
E both smoke and air particles moving randomly. N91/I/12

5 Some gas is heated in a sealed container.

Which of the following does **not** increase?

A the force due to the collisions between the gas molecules and the container walls .
B the number of collisions per second by the gas molecules on the container walls
C the average kinetic energy of gas molecules
D the average speed of the gas molecules
E the average distance between gas molecules N91/I/13

6 Some gas trapped in a cylinder is compressed at constant temperature by a piston. Which of the following will **not** change?

A density
B mass
C molecular spacing
D pressure
E volume J92/I/11

7 When the temperature of a gas rises at constant volume, its molecules

A move closer together.
B move with greater average speed.
C collide with one another less often.
D exert smaller forces on one another.
E expand. N92/I/12

8 When a solid is heated, which of the following changes occurs?

A The density increases.
B The latent heat increases.
C The melting point increases.
D The molecules vibrate more rapidly.
E The number of molecules increases. J93/I/12

9 Which states of matter are very difficult to compress?

- **A** gases only
- **B** gases and liquids only
- **C** gases, liquids and solids
- **D** liquids and solids only
- **E** solids only

N93/I/11

10 A fixed mass of gas is heated while kept at constant volume. How do the properties of the molecules of the gas change?

	average speed	*frequency of collision with walls*	*average distance apart*
A	increases	increases	unchanged
B	increases	increases	decreases
C	increases	unchanged	unchanged
D	unchanged	increases	increases
E	unchanged	unchanged	decreases

N93/I/12

11 Why does the pressure of a fixed mass of gas increase when it is heated at constant volume?

- **A** More molecules are created by the heating.
- **B** The average mass of the molecules increases.
- **C** The average speed of the molecules increases.
- **D** The molecular collisions become more elastic.

J94/I/13

12 The Brownian motion of smoke particles is caused by

- **A** collisions between air molecules.
- **B** collisions between smoke particles.
- **C** collisions between smoke particles and air molecules.
- **D** convection currents in the air.

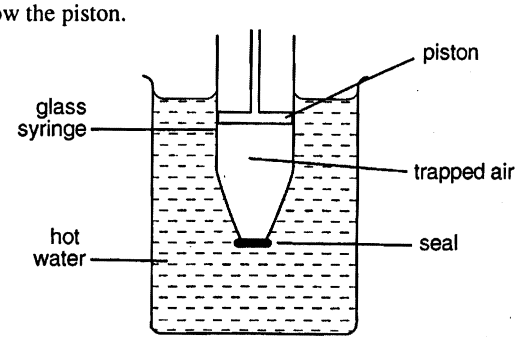
N94/I/12

13 Which of the following gives the states of matter in which molecules, at a given temperature, have the highest speed and the greatest force of attraction between them?

	state in which molecules have the highest speed	*state in which molecules have the greatest force between them*
A	gas	gas
B	gas	solid
C	solid	gas
D	solid	solid

N96/I/12

14 The outlet of a glass syringe is sealed so that air is trapped below the piston.



Which of the following explains why the piston begins to rise when the syringe is placed in hot water?

- **A** The molecules of trapped air are getting bigger.
- **B** Convection is occurring inside the syringe.
- **C** The glass is expanding.
- **D** The trapped air molecules are hitting the piston more often.

N96/I/13

15 A substance which flows under the action of an external pressure may be

- **A** a gas, but not a liquid or a solid.
- **B** a gas or a liquid, but not a solid.
- **C** a gas or a solid, but not a liquid.
- **D** a liquid or a solid, but not a gas.

J96/I/12

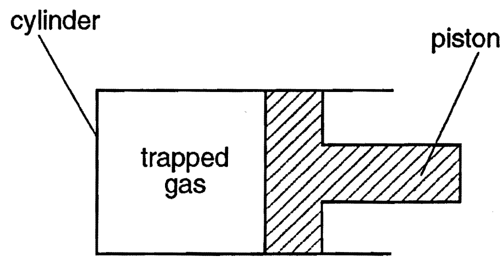
16 A balloon is squeezed and the pressure of the air inside increases.

If there is no change in the temperature of the air, the molecules of air cause this increase in pressure; because they

- **A** are greater in number.
- **B** are moving faster.
- **C** collide more frequently with the wall of the balloon.
- **D** have a larger mean free path.

N97/I/13

17 The cylinder shown contains a gas. The piston is held fixed and the cylinder is heated.

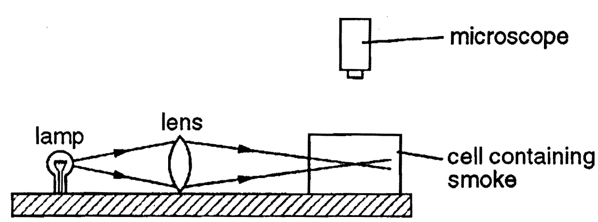


Why does the pressure of the trapped gas increase?

- **A** The gas molecules expand.
- **B** The molecules move at the same speed but hit the walls more often.
- **C** The molecules move faster and hit the walls more often.
- **D** The number of molecules of gas increases.

J98/I/12 ; N2000/I/11

18 Brownian motion of smoke particles can be studied by using the apparatus shown.



What causes the Brownian motion?

A convection currents in the air
B heat from the lamp
C random collisions between air molecules and smoke particles
D random collisions between smoke particles and other smoke particles J93/I/11 ; N98/I/12

19 How are the forces between the molecules in a gas and the average speed of these molecules best described?

	forces between molecules	average speed of molecules
A	very strong	very slow
B	strong	fast
C	weak	slow
D	very weak	very fast

J99/I/12

20 When the Brownian motion of smoke particles in air is observed with a microscope, moving points of light are seen.

These points of light are reflections from

A air particles only, moving randomly.
B smoke particles only, moving randomly.
C smoke particles only, vibrating.
D both smoke and air particles, moving randomly.

N99/I/11

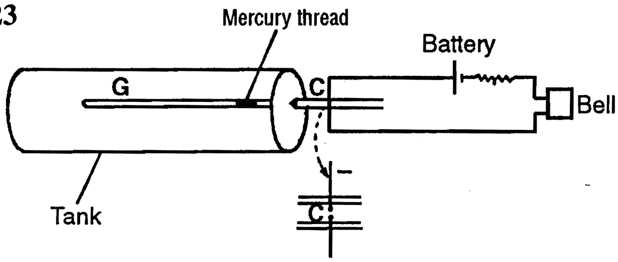
21 Which of the following correctly states the properties of solids, liquids and gases?

	solids	liquids	gases
A	do not flow easily	flow easily	flow easily
B	easily compressed	easily compressed	hard to compress
C	fixed shape	fixed shape	no fixed shape
D	no fixed volume	fixed volume	no fixed volume

J2000/I/11

22 How does the kinetic theory of gases explain the pressure exerted on the walls of the container by a gas? Why does this pressure increase when the temperature is increased at constant volume? J79/II/8

23



The diagram illustrates a device, based upon expansion, designed to give an audible warning when the temperature inside the cylindrical tank rises to a particular value. The glass tube G contains a sample of dry air enclosed by a mercury thread. There is a small gap between the two electrical contacts C which are sealed through the sides of the glass tube.

(a) Explain briefly what will occur as the temperature inside the tank rises until the warning is given.

(b) State **two** reasons why the change in volume of the air inside G is much greater than the change in volume of the mercury thread.

(c) When the atmospheric pressure increases, what change will be produced in the position of the mercury thread?

What effect will this change have on the temperature at which the warning is heard?

N79/II/2

24 Describe an experiment to demonstrate Brownian motion, stating clearly what you would observe. Explain how the observations you have described support the kinetic theory. In what way would you expect your observations to differ if the experiment were repeated at a lower temperature?

Use your knowledge of the kinetic theory to explain

(a) how a gas exerts a pressure on the walls of a vessel containing it,

(b) why the pressure exerted by the gas increases when the temperature is raised but the volume is kept constant.

N79/II/7

25 Air at a pressure of 750 mm Hg is contained in a cylinder fitted with a piston. The piston is moved so that the same mass of air occupies one-fifth of its original volume without any change in temperature. Calculate the new pressure of the air.

Account for the pressure change in terms of the simple kinetic theory of gases. J81/I/4

26 An inflated car tyre is considered to have a constant volume regardless of any changes in temperature or pressure. Use the kinetic theory of gases to answer the following.

(a) How does the air in the tyre exert a pressure on the walls of the tyre?

(b) Why is the pressure the same at all points on the inside wall of the tyre?

(c) What happens to the pressure on the inside walls of the tyre if the temperature of the air increases? Explain your answer.

(d) More air is pumped into the tyre whilst the temperature is kept constant until there are twice as many molecules as before. Explain why you would expect the pressure to be doubled.

J81/II/2

27 Describe the nature of liquids and of gases in terms of the movement of their molecules and the forces between them.

Illustrate your answer with suitable diagrams, making clear how the two states differ.

What is *Brownian motion*? Describe an experiment to demonstrate this effect. Include in your answer labelled diagrams of *(a)* the apparatus which would be used, *(b)* the observations which would be made.

Give an explanation, in terms of the kinetic theory, of the expansion of a gas when heated at constant pressure.

J82/II/8

28 Using your knowledge of the simple kinetic theory of gases, explain in terms of the movement of molecules

(a) the effect on the molecules of raising the temperature of a gas,

(b) what becomes of the energy used to heat a gas, its volume being kept constant,

(c) why smoke particles in air exhibit continuous random motion that can be observed under a microscope.

N82/II/8*(a), (b), (c)*

29 Smoke particles suspended in air in a closed glass box are illuminated from the side. They are viewed through a microscope mounted vertically above the box.

(a) (i) Why is it not possible to see the molecules of air in the box?

(ii) Why are the smoke particles illuminated from the side?

(b) When the particles are observed they are seen to move continuously.

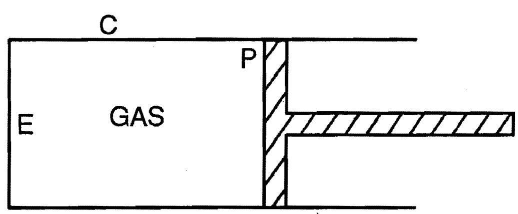
(i) Describe with the aid of a diagram the motion of any one of the smoke particles in the box.

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

(c) What would be the effect on the movement of the smoke particles of increasing the temperature of all the air in the box? Explain your answer.

N85/II/2

30 The diagram shows a stationary frictionless gas-tight piston P in a cylinder C which contains gas. How may the kinetic theory of gases be used to account for the following facts?



(i) The gas in the cylinder exerts a pressure on P.

(ii) This pressure is atmospheric pressure.

(iii) The pressure on P is equal to that on the end E of the cylinder.

The pressure of the gas is 1.0×10^5 Pa.

The piston is now moved to the left so that the gas is compressed and arrangements are made to keep the temperature of the gas constant. The average force exerted by the gas on the piston during the change is 70 N, and the piston moves 0.30 m so that the volume of the gas is reduced by one-tenth.

Calculate

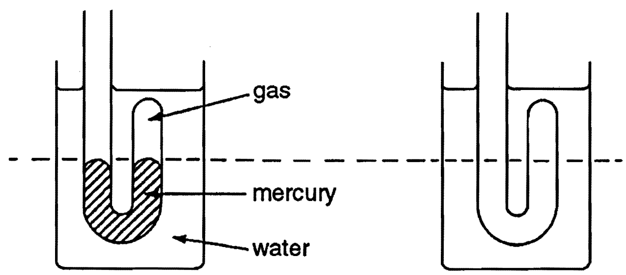
(i) the work done on the gas,

(ii) the final pressure of the gas.

In real circumstances would you expect the temperature of the gas to rise as it is compressed?

N85/II/8

31 Fig. (i) shows a tube containing gas and mercury at room temperature. Indicate on Fig. (ii) the mercury levels when the water is heated to a higher steady temperature.



room temperature

Fig. (i)

higher steady temperature

Fig. (ii)

Using your knowledge of the kinetic theory, explain the new position of the mercury surface in contact with the gas.

J86/I/3

32 State the effect of a rise in temperature on the motion of the molecules of a gas.

A gas in an enclosed container is heated uniformly. Assuming the volume of the container does not change, use the simple kinetic theory to explain the effect of this heating on the pressure which the gas exerts on the container.

N86/I/4

33 What is a fluid?

The molecules of a particular substance are identical, whether in the liquid or gaseous state. With reference to the *molecules*, give

(i) one similarity between the liquid and gaseous states,

(ii) one difference between the liquid and gaseous states.

Why is energy needed to convert a liquid into a gas at the same temperature?

N87/I/7

34 *(a)* A sample of air exerts a pressure on the walls of its container. Use your knowledge of the kinetic theory to answer the following questions.

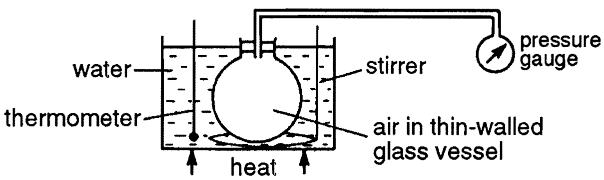
(i) The pressure exerted on each part of the walls is the same. What deductions about the motion of the molecules in the air sample can be made from this fact?

(ii) How does the motion of the molecules of the air sample change when the container and the air inside it are heated?

State and explain how the change affects the pressure exerted by the gas.

(iii) How does the expansion of the *container* affect the change in pressure you describe? [8]

(b) The apparatus in the diagram is arranged so that the pressure p of a sample of air at various temperatures θ but at constant volume can be measured.



(i) Explain how you would obtain the readings of p and θ.

(ii) Select *two* features of the apparatus and indicate how they improve the accuracy of the values which are obtained. [5]

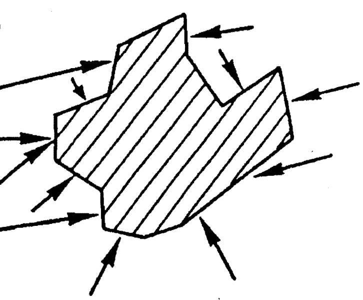
J88/II/8

35 The diagram below shows a magnified dust particle floating in air. Draw on the diagram a possible path that the dust particle might follow. Mark the direction of motion along the path by an arrow. [2]

(i)

In the diagram below the dust particle has been further magnified. The air molecules hitting the particle at a given instant are indicated by lines with arrows. The speed of each molecule is indicated by the length of the line.

(ii)



(i) Why does the particle move? [1]

(ii) Show by an arrow, labelled D, the direction in which you would expect the particle to move initially. [1]

N88/I/5

36 A cylinder of volume 5.0×10^{-3} m^3 contains carbon dioxide gas at a pressure 6.0×10^5 Pa and a temperature 20 °C. Given that the internal area of the flat base of the cylinder is 2.2×10^{-1} m^2, calculate the total force on the base due to the gas pressure. [2]

The valve on the cylinder is opened and gas escapes until the mass of gas which originally occupied exactly half the volume of the cylinder now occupies the whole cylinder. Given that the temperature of the gas remaining in the cylinder has fallen from 20 °C to 0 °C, calculate the pressure of gas now in the cylinder. [4]

In terms of the kinetic theory of gases, explain why

(i) the reduction in the mass of gas in the cylinder leads to a decrease in pressure in the cylinder, [2]

(ii) the fall in temperature leads to a further decrease in pressure. [2] N88/II/2

37 Fig. 1 shows an experiment to observe the Brownian motion of smoke particles in air.

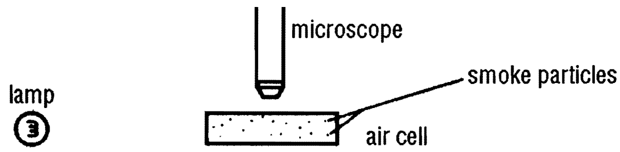


Fig. 1

(a) Draw a diagram to illustrate the motion of one of the smoke particles. [3]

(b) Explain the motion of the smoke particles using simple kinetic theory. [2]

J89/I/5

38 *(a)* A sealed flask contains a gas.

(i) Describe the motion of the gas molecules.

(ii) Explain how the motion of the gas molecules results in a pressure exerted by the gas on the walls of the flask. [6]

(b) (i) Explain what is meant by *Brownian motion.*

(ii) With the aid of a labelled diagram, describe an experiment to demonstrate Brownian motion. [5]

(c)

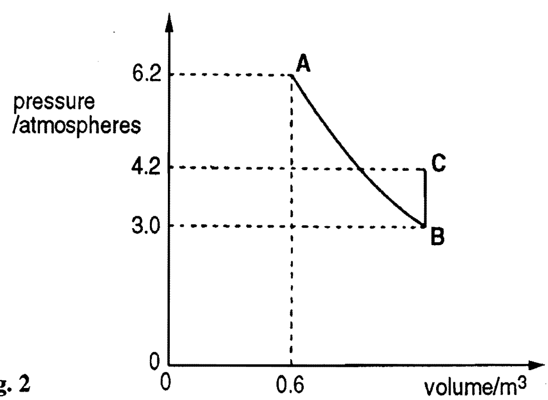


Fig. 2

The graph in Fig. 2 shows changes of pressure and volume of a fixed mass of gas. **AB** represents a change taking place at a constant temperature of 20 °C. **BC** represents a further change for the same mass of gas.

(i) Use the values of pressure and volume given on the graph to calculate the volume of **B**. [2]

(ii) Explain the nature of the change represented by **BC**. [2] N89/II/8

39 Fig. 3 shows the main parts of a bicycle pump with the end blocked up. When a bicycle tyre is pumped up, the volume of the air trapped in the pump is reduced and its pressure is increased.

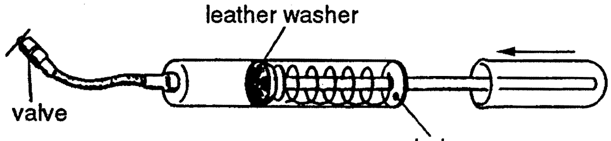


Fig. 3

(a) Explain, in terms of the motion of molecules, why the pressure increases. [2]

(b) The volume of air in the pump at the start of the stroke is 20 cm^3, and the pressure of the air is 1.00×10^5 Pa.

Calculate the pressure when the volume has been reduced to 8.0 cm^3, assuming that no air has escaped from the pump and the temperature of the air is constant. [2]

(c) In practice, the temperature of the air increases as it is compressed. Explain why this is so. [2]
N90/II/4

40 State **briefly** how you would demonstrate *Brownian motion* and explain why such motion suggests that fluids are made up of moving molecules. [5] J91/II/4

41 *(a)* (i) What property of molecules gives solids and liquids their definite volumes?

(ii) What property of molecules makes gases fill all the space available to them? [2] J93/II/2*(a)*

42 *(a)* (i) Write down the forms of energy possessed by an atom in a solid.

(ii) Draw a labelled diagram or diagrams to illustrate the arrangements and the motions of atoms in a **solid**.

(iii) Draw a labelled diagram or diagrams to illustrate the arrangements and the motions of molecules in a **gas**. [5]

(b) State what is meant by

(i) the gravitational potential energy,

(ii) the kinetic energy,

(iii) the internal energy,

of a body. [3]

(c) A lead cube of mass 0.25 kg falls from rest from a height of 12 m to the ground. Calculate, neglecting frictional losses,

(i) the loss of potential energy of the cube,

(ii) the gain of kinetic energy of the cube,

(iii) the speed of the cube when it hits the ground,

(iv) the rise in temperature of the cube after it hits the ground, assuming that all the kinetic energy is changed into internal energy of the cube.

The gravitational force on a mass of 1 kg = 10 N.

The specific heat capacity of lead = 0.13 kJ/(kg K). [7]
N94/II/10

43 *(a)* (i) What is seen moving when *Brownian motion* is observed?

(ii) Why is a microscope necessary in order to observe Brownian motion?

(iii) Explain how Brownian motion provides evidence for the kinetic molecular model of matter. [4]
J96/II/4*(a)*

44 *(a)* Describe briefly the differences between the motions of the molecules of ice, water and steam. [3]

(b) State and explain what happens to the molecules in a block of ice when the temperature of the ice is increased and the ice does not melt. [2]

**(c)* Explain, in terms of the energy changes involved, why a liquid cools as it evaporates. [3]
J97/II/3

45 *(a)* Draw a labelled diagram of the apparatus you would use to demonstrate Brownian motion. [4]

(b) Explain clearly what an observer, using the apparatus you have drawn, would see. [2]

(c) State and explain the conclusions that can be drawn from Brownian motion. [3]
N97/II/5

46 *(a)* A syringe contains trapped air, as shown in Fig. 4.1. The piston inside the syringe is free to move up and down in the syringe. When the syringe is placed in hot water, the air inside expands, as shown in Fig. 4.2.

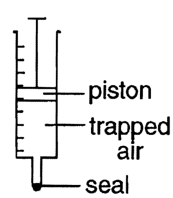


Fig. 4.1 syringe in cold water

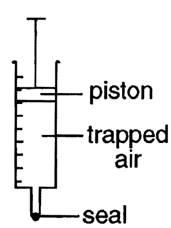


Fig. 4.2 syringe in hot water

Explain, in terms of the motion of the molecules,

(i) why the air inside the syringe exerts a pressure on the piston,

(ii) why the piston is pushed upwards when the syringe is placed in hot water. [4]

(b) Another syringe contains 80 cm^3 of trapped air at room temperature. The piston is slowly pushed inwards, compressing the air. Some information about the air inside the syringe is given in the table below.

	before compression	after compression
volume of air	80 cm^3	20 cm^3
temperature of air	25 °C	25 °C
pressure of air	1.0×10^5 Pa	P

Calculate the pressure P of the air after compression. [1]

N98/II/3

47 Explain, by writing about molecules,

(a) how the air inside a car tyre exerts a pressure on the walls of the tyre, [2]

(b) why the pressure in the car tyre increases as the tyre becomes hotter, [2]

(c) why the pressure in the tyre increases as more air is pumped into the tyre. [1]

J99/II/7

48 Fig. 5 illustrates the arrangement of molecules of a substance in different states of matter.

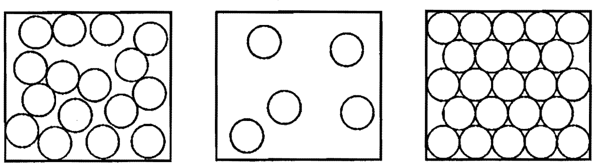


Fig. 5

(a) State which arrangement A, B or C represents the structure of

the solid, ...

the liquid, ...

the gas. .... [1]

(b) Explain why the density of the gas is lower than that of the solid. [1]

(c) Describe the movement of the molecules in

(i) the solid,

(ii) the liquid,

(iii) the gas. [4]

N99/II/2

49 Brownian motion is the motion of tiny particles suspended in a liquid or gas. It can be seen when smoke in a sealed container is observed by using a microscope.

(a) Explain what causes *Brownian motion.* [2]

(b) Draw a diagram to show the **motion** of a smoke particle seen through the microscope. [1]

(c) Convection currents do not cause Brownian motion. Suggest what is observed when the smoke particles are in a convection current. [1]

N2000/II/3

ANSWERS

1. **A**	2. **C**	3. **D**	4. **C**	5. **E**
6. **B**	7. **B**	8. **D**	9. **D**	10. **A**
11. **C**	12. **C**	13. **B**	14. **D**	15. **B**
16. **C**	17. **C**	18. **C**	19. **D**	20. **B**
21. **A**				

25. 3750 mm Hg

30. (i) 21 J (ii) 1.11×10^5 Pa

36. 1.32×10^4 N

39. *(b)* 2.5×10^5 Pa

42. *(c)* (i) 30 J (ii) 30 J (iii) 15.5 m/s (iv) 0.923 °C

46. *(b)* 4×10^5 Pa

48. *(a)* C ; A ; B