

Chapter 2

Thermal physics

2.1 Kinetic particle model of matter



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01.0625_s23_qp_42 Q:4

- (a) The temperature of a fixed mass of gas at constant volume is decreased.

State and explain, in terms of particles, how the pressure of the gas changes.

.....
.....
.....
..... [3]

- (b) (i) State the value of absolute zero in °C.

value of absolute zero = °C [1]

- (ii) Explain what is meant by the term absolute zero. Refer to particles in your answer.

.....
.....
..... [2]

- (c) Cylinder 1 contains 350cm^3 of gas at a pressure of $9.0 \times 10^4\text{Pa}$. The gas is transferred to cylinder 2 and the pressure increases to $1.6 \times 10^5\text{Pa}$. The temperature remains constant.

Calculate the volume of cylinder 2.

volume = [3]



2.1. KINETIC PARTICLE MODEL OF MATTER

02.0625_w23_qp_41 Q:3

Liquids are difficult to compress whereas gases can be compressed easily.

(a) Explain, in terms of particles, why it is difficult to compress liquids.

.....

 [2]

(b) Fig. 3.1 shows a rectangular block floating in water. The density of the water is 1000 kg/m^3 .

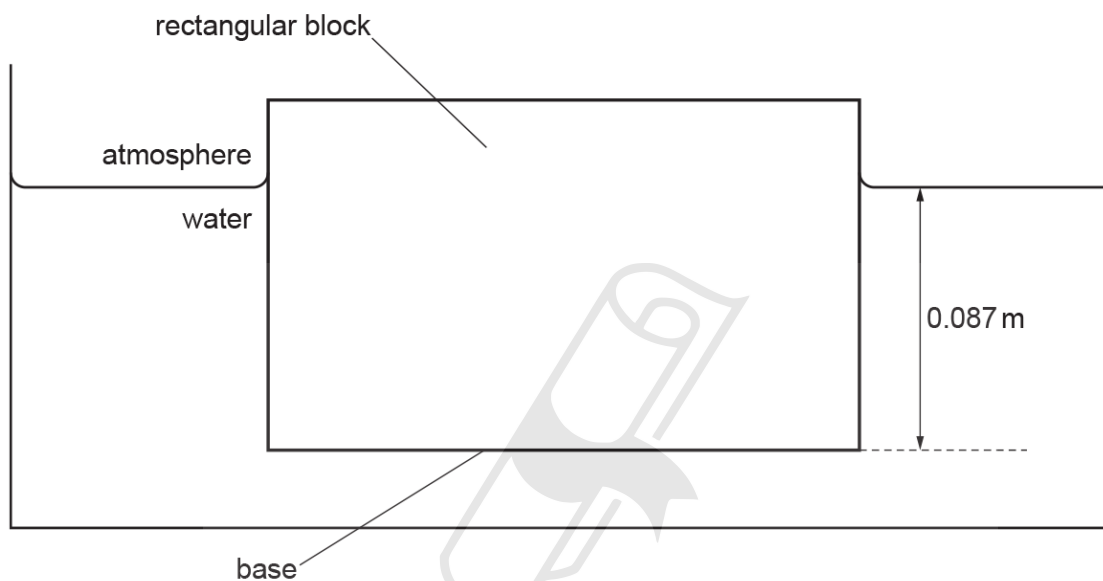


Fig. 3.1

The area of the base of the block is 0.014 m^2 . The base of the block is at a depth of 0.087 m below the surface of the water.

(i) Show that the pressure due to the water at the base of the block is approximately 850 Pa .

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[2]

(ii) Calculate the force F on the base of the block caused by the pressure given in (b)(i).

$F = \dots\dots\dots$ [2]

(iii) Force F is equal to the weight of the block.

Calculate the mass of the block.

mass = $\dots\dots\dots$ [2]

03.0625_w23_qp_43 Q:4

(a) The lowest possible temperature is zero kelvin (0 K).

(i) State the name of this lowest possible temperature.

..... [1]

(ii) Nitrogen boils at 77 K.

Calculate the boiling point of nitrogen on the Celsius scale.

boiling point = °C [2]

(b) The temperature of a fixed mass of gas at constant volume changes from 300 K to 400 K.

State and explain, in terms of particles, the effect on the pressure of the gas.

statement

explanation

.....

.....

.....

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(c) A sample of gas is at a pressure of 120 kPa. The volume of the gas is doubled at constant temperature.

Calculate the new pressure of the gas.

pressure = [2]

2.1. KINETIC PARTICLE MODEL OF MATTER

04.0625_s22_qp_43 Q:4

(a) Fig. 4.1 shows apparatus used to observe the motion of smoke particles (Brownian motion).

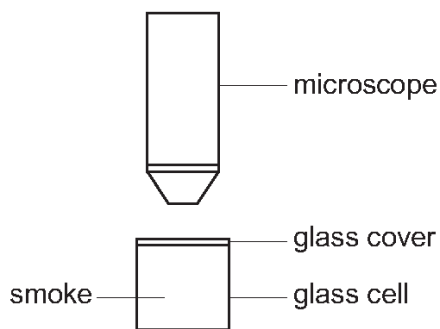


Fig. 4.1

The glass cell has light shining on it from the side.

The smoke particles are seen as bright specks of light when looking through the microscope.

(i) Draw the path of **one** of the bright specks of light.

[2]

(ii) Explain, in terms of forces and the motion of air molecules, the cause of the motion of the smoke particles.

.....
.....
.....
.....
..... [4]

(b) The temperature of the air in a sealed glass container is increased.

(i) Explain, in terms of molecules, why the internal energy of the air increases.

.....
..... [1]

(ii) Explain, in terms of molecules, why the pressure of the air also increases.

.....
.....
..... [2]

05.0625_w22_qp_42 Q:4

(a) Explain, in terms of the momentum of particles, how a gas exerts a pressure.

.....
.....
.....
..... [3]

(b) The temperature of a sample of gas is increased at constant volume.

State and explain any change in the pressure of the gas.

.....
.....
.....
..... [2]

(c) Another sample of gas is in a sealed container of volume 170 cm^3 and exerts a pressure of $9.0 \times 10^4 \text{ Pa}$. The volume of the container decreases by 70 cm^3 at constant temperature.

Calculate the new pressure of the gas.

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pressure = [3]

2.1. KINETIC PARTICLE MODEL OF MATTER

06.0625_m21_qp_42 Q:4

(a) In terms of the momentum of molecules, explain how a gas exerts pressure on the walls of its container.

.....
.....
.....
.....
.....
.....
..... [4]

(b) A fixed mass of gas of volume V_1 is at a pressure p_1 . It is compressed to a volume V_2 .

(i) Complete the equation for the final pressure p_2 of the gas when the gas is compressed at constant temperature.

$p_2 =$ [2]

(ii) State and explain how the final pressure compares with p_2 when the temperature of the gas increases during compression.

statement

explanation

.....
.....
..... [3]

[Total: 9]

07.0625_s21_qp_41 Q:3

(a) Explain, in terms of molecules, why liquids are very difficult to compress.

.....

 [2]

(b) Fig. 3.1 shows a device that uses liquid pressure to lift heavy boxes.

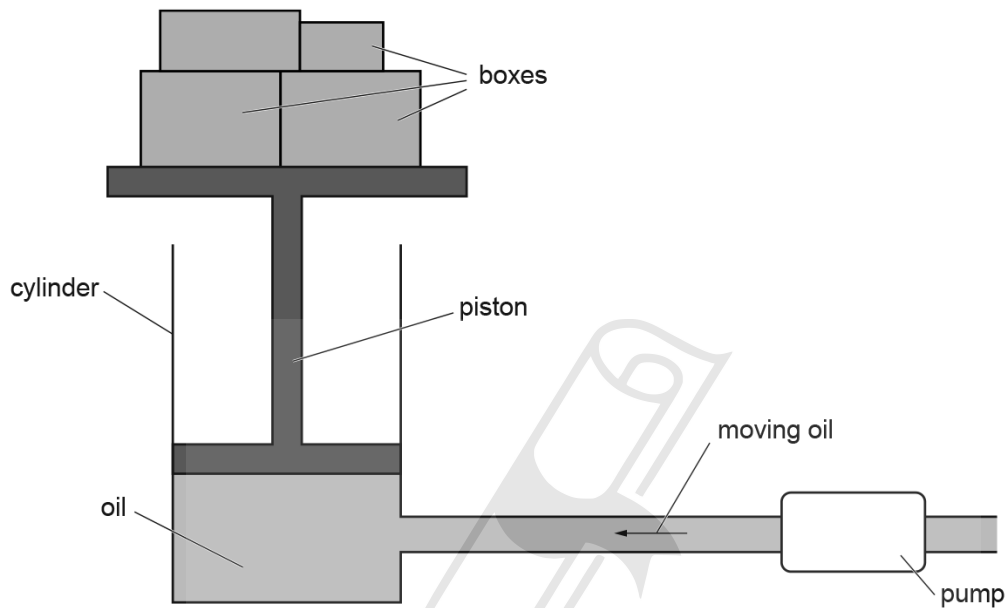


Fig. 3.1

The boxes are lifted by pumping oil into the cylinder.

The force upwards on the piston due to the oil, and the force downwards on the piston due to the air above the piston, combine to produce a constant force of 8800 N.

The pressure of the air is $1.0 \times 10^5 \text{ Pa}$ and the cross-sectional area of the bottom surface of the piston is 0.016 m^2 .

(i) Calculate the pressure of the oil at the bottom surface of the piston.

pressure = [3]

2.1. KINETIC PARTICLE MODEL OF MATTER

(ii) As the boxes are lifted, the depth of the oil increases.

Explain why the pump must exert an increasing pressure on the oil as the depth of the oil increases.

.....
.....
..... [2]

(iii) Suggest **one** reason why the force of 8800 N in (b) cannot lift boxes of weight 8800 N.

.....
..... [1]

[Total: 8]



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08.0625_w21_qp_41 Q:3

Fig. 3.1 shows a balloon inflated with air.

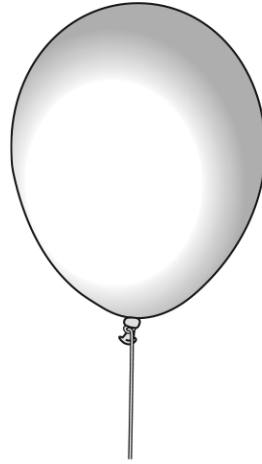


Fig. 3.1

The pressure of the air at the inner surface of the balloon keeps the rubber stretched.

- (a) Explain, in terms of the momentum of the molecules, why there is a pressure at the inner surface of the balloon.

.....

.....

.....

..... [3]

- (b) The volume of the air in the balloon is 630 cm^3 and the pressure of the air in the balloon is $1.0 \times 10^5 \text{ Pa}$.

The balloon is tied to a heavy stone and dropped into a lake. The balloon is pulled down quickly and the temperature of the air inside does **not** change.

- (i) Calculate the volume of the air when the pressure of the air is $1.4 \times 10^5 \text{ Pa}$.

volume = [2]

2.1. KINETIC PARTICLE MODEL OF MATTER

- (ii) The balloon and stone stop moving when the stone hits the bottom of the lake. The temperature of the air now begins to decrease.

Explain why the volume of the air in the balloon decreases as the temperature decreases.

.....

.....

.....

..... [2]



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09.0625_w21_qp_43 Q:3

(a) A gas bubble is released at the bottom of a lake.

Atmospheric pressure is $1.0 \times 10^5 \text{ Pa}$. The density of water is 1000 kg/m^3 . The temperature of the water in the lake is constant.

(i) The gas bubble rises to the surface. The volume of the gas bubble increases as it rises higher in the water.

Explain why the volume of the bubble increases.

.....
.....
..... [2]

(ii) The volume of the gas bubble is 0.40 cm^3 when it is 3.0 m below the surface of the lake.

Calculate the volume of the gas bubble when it is 0.50 m below the surface of the lake.



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volume = [4]

2.1. KINETIC PARTICLE MODEL OF MATTER

(b) Fig. 3.1 shows a diagram of a hydraulic press used to compress paper for recycling.

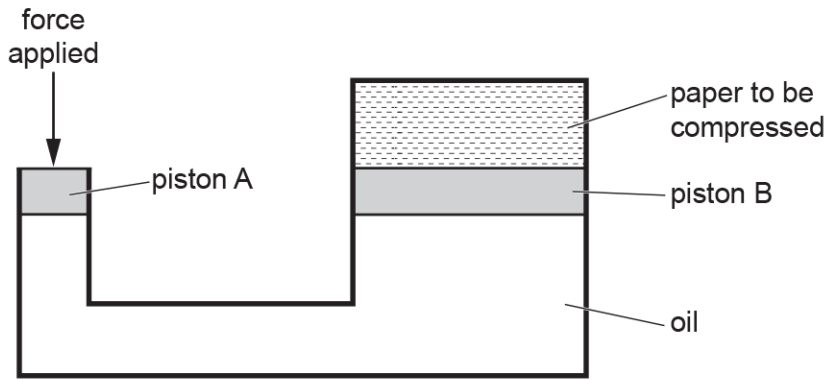


Fig. 3.1

When a force is applied to piston A, it causes a pressure in the oil. This pressure produces an upwards force on piston B. As piston B moves, it compresses the paper.

A small quantity of air leaks into the oil.

Suggest and explain the effect the air has on the operation of the hydraulic press.

.....

.....

.....

..... [2]

10. 0625_w21_qp_43 Q:4

Explain what happens to the pressure of a constant volume of air when the temperature of the air increases. Use ideas of momentum of molecules in your explanation.

.....

.....

.....

.....

.....

.....

..... [4]

11. 0625_s20_qp_41 Q:3

Fig. 3.1 shows gas trapped in the sealed end of a tube by a dense liquid.

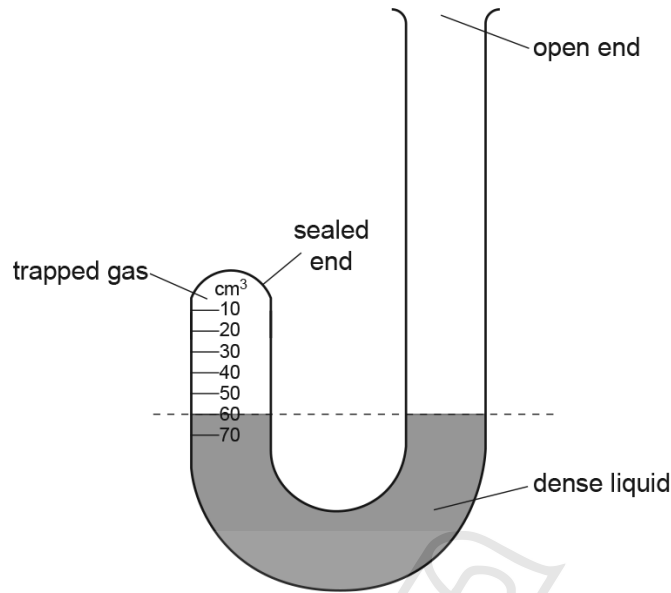


Fig. 3.1

The scale marked on the sealed end of the tube is calibrated to read the volume of gas trapped above the liquid surface. Fig. 3.1 shows that initially the volume V_1 of the gas is 60 cm^3 .

The pressure of the atmosphere is $1.0 \times 10^5\text{ Pa}$.

- (a) State how Fig. 3.1 shows that the pressure of the trapped gas is equal to the pressure of the atmosphere.

.....
 [1]

- (b) Explain, in terms of the momentum of its molecules, why the trapped gas exerts a pressure on the walls of the tube.

.....

 [3]

2.1. KINETIC PARTICLE MODEL OF MATTER

- (c) More of the dense liquid is poured into the open end of the tube. The level of the liquid surface in both the sealed and the open ends of the tube rises as shown in Fig. 3.2. The temperature of the trapped gas and atmospheric pressure both remain constant.

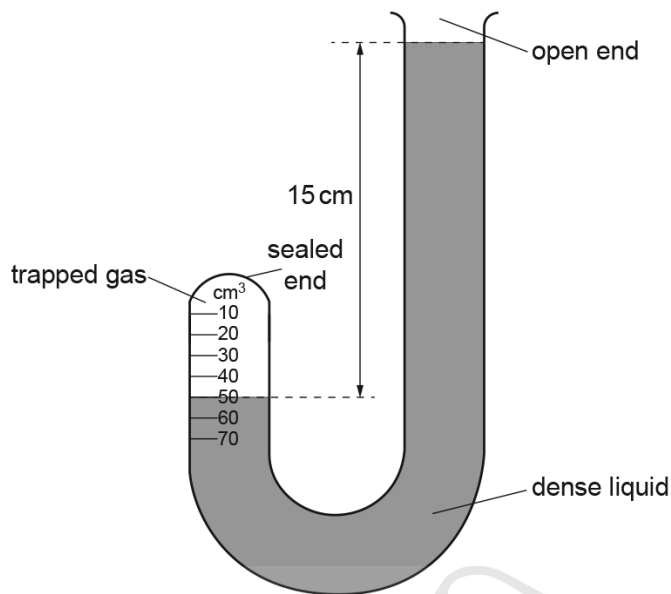


Fig. 3.2

- (i) In the sealed end of the tube, the volume V_2 of the trapped gas is 50 cm^3 . In the open end of the tube, the liquid surface is 15 cm above the new level in the sealed tube.

Calculate the pressure p_2 of the trapped gas.

pressure $p_2 = \dots\dots\dots$ [2]

- (ii) Calculate the density of the liquid in the tube.

density = $\dots\dots\dots$ [2]

[Total: 8]

12. 0625_w20_qp_43 Q:4

In Fig. 4.1, the circles represent molecules in different states of matter.

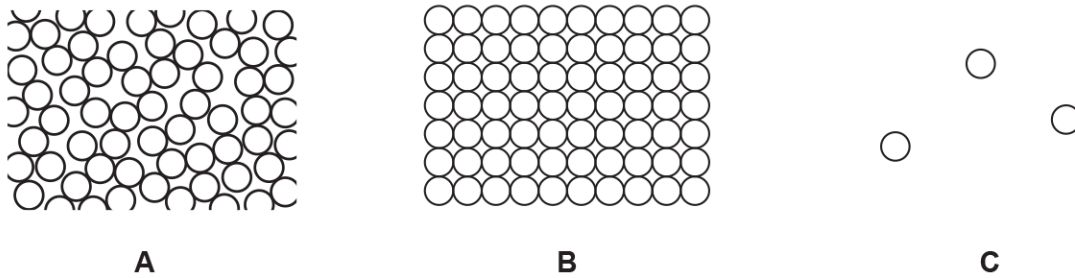


Fig. 4.1

(a) Identify the states **A**, **B** and **C**.

A

B

C

[2]

(b) Explain, in terms of forces between molecules, why gases expand more than liquids when they have the same rise in temperature. Assume that the pressure remains constant.

.....

 [2]

(c) Fig. 4.2 shows a cylinder and piston.

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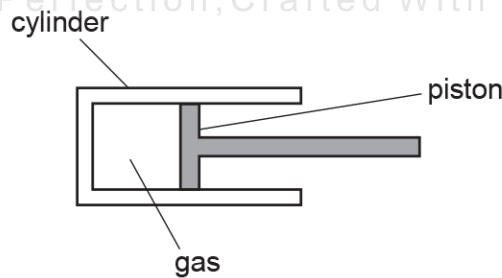


Fig. 4.2

The volume of gas in the cylinder is 3400 cm^3 . The pressure of the gas in the cylinder is $0.90 \times 10^5 \text{ Pa}$.

2.1. KINETIC PARTICLE MODEL OF MATTER

- (i) The piston is moved to the left and fixed in a new position. The pressure of the gas in the cylinder increases to 2.5×10^5 Pa. Assume that the temperature of the gas does not change.

Calculate the new volume of the gas.

volume = [3]

- (ii) The gas in the cylinder is now heated. The piston remains fixed in the same position as in (c)(i).

State and explain, in terms of molecules, any change in the pressure of the gas.

statement

explanation

.....

[3]



13.0625_m19_qp_42 Q:5

(a) State the values of the *fixed points* of a temperature scale.

..... [1]

(b) (i) The graduations on a liquid-in-glass thermometer are equally spaced.

For the equal spacing of the graduations to be correct, state:

1. an assumption that is made about the liquid in the thermometer

.....

2. an assumption that is made about the structure of the thermometer.

.....

[2]

(ii) Liquid-in-glass thermometer A has a greater range than liquid-in-glass thermometer B.

State **one** way the design of thermometer A is different from thermometer B.

.....

..... [1]

(iii) Liquid-in-glass thermometer C has a greater sensitivity than liquid-in-glass thermometer D.

State **one** way the design of thermometer C is different from thermometer D.

.....

..... [1]



2.1. KINETIC PARTICLE MODEL OF MATTER

(c) (i) In the space provided, draw a labelled diagram of a thermocouple thermometer.

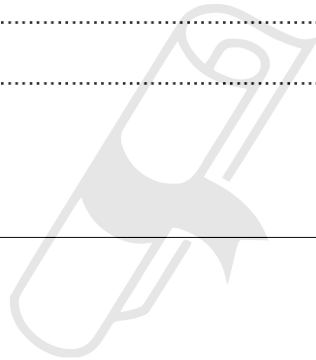
[3]

(ii) Suggest when a thermocouple thermometer is more suitable than a liquid-in-glass thermometer.

.....
.....

[1]

[Total: 9]



14.0625_m19_qp_42 Q:7

(a) In Fig. 7.1, the small circles represent molecules. The arrows refer to the change of state from the arrangement of molecules on the left to the arrangement of molecules on the right.

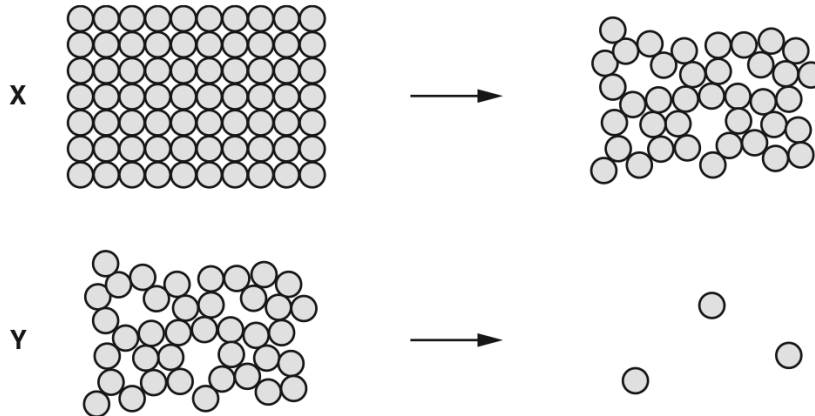


Fig. 7.1

Complete the following by writing solid, liquid or gas in each of the blank spaces.

1. Change of state X is from to
2. Change of state Y is from to [2]

(b) Explain, in terms of the forces between their molecules, why gases expand more than solids when they undergo the same rise in temperature.

.....

 [2]

(c) A cylinder of volume 0.012m^3 contains a compressed gas at a pressure of $1.8 \times 10^6\text{Pa}$. A valve is opened and all the compressed gas escapes from the cylinder into the atmosphere.

The temperature of the gas does not change.

Calculate the volume that the **escaped** gas occupies at the atmospheric pressure of $1.0 \times 10^5\text{Pa}$.

volume = [3]

[Total: 7]

2.1. KINETIC PARTICLE MODEL OF MATTER

15.0625_s19_qp_41 Q:3

A cube of side 0.040 m is floating in a container of liquid. Fig. 3.1 shows that the surface of the liquid is 0.028 m above the level of the bottom face of the cube.

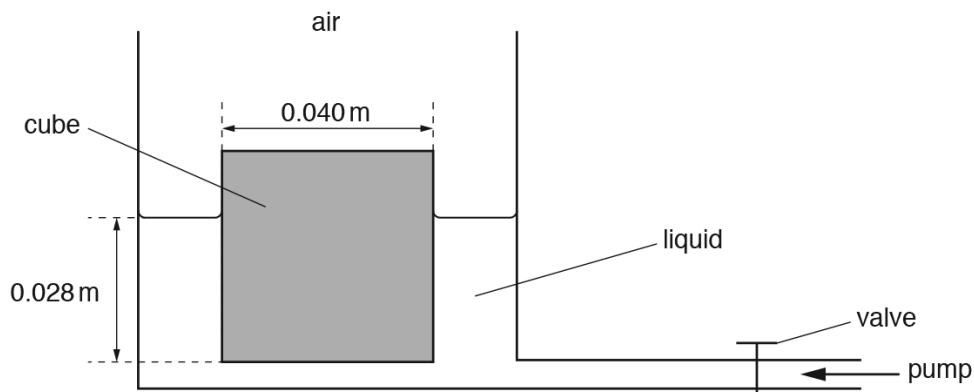


Fig. 3.1

The pressure of the air above the cube exerts a force on the top face of the cube. The valve is closed.

- (a) Explain, in terms of air molecules, how the force due to the pressure of the air is produced.

.....

 [3]

- (b) The density of the liquid in the container is 1500 kg/m^3 .

Calculate:

- (i) the pressure due to the liquid at a depth of 0.028 m

pressure = [2]

- (ii) the force on the bottom face of the cube caused by the pressure due to the liquid.

force = [2]

- (c) The valve is opened and liquid is pumped into the container. The surface of the liquid rises a distance of 0.034 m.

The cube remains floating in the liquid with its bottom face 0.028 m below the surface of the liquid.

- (i) Calculate the work done on the cube by the force in (b)(ii).

work done = [2]

- (ii) Suggest **one** reason why this is **not** an efficient method of lifting up the cube.

.....
..... [1]

[Total: 10]



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2.1. KINETIC PARTICLE MODEL OF MATTER

16.0625_w19_qp_41 Q:3

Fig. 3.1 shows a shooting competition, where air rifles fire soft metal pellets at distant targets.

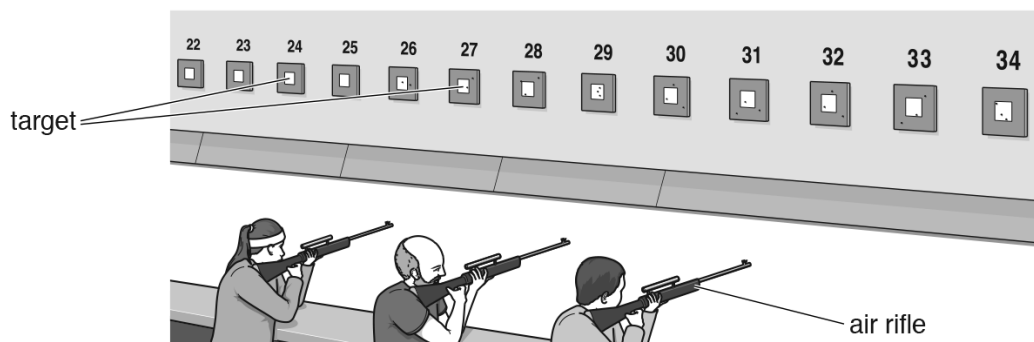


Fig. 3.1

When an air rifle is fired, it exerts an impulse of 0.019 N s on the pellet.

(a) Define *impulse*.

.....
..... [1]

(b) The pellet has a mass of 1.1×10^{-4} kg.

Determine:

(i) the speed with which the pellet leaves the rifle

speed = [2]

(ii) the kinetic energy of the pellet as it leaves the rifle.

kinetic energy = [3]

(c) The pellet melts when it strikes the target.

Describe how the molecular structure of the liquid metal differs from that of the solid metal.

.....
.....
.....
..... [3]

[Total: 9]



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2.1. KINETIC PARTICLE MODEL OF MATTER

17.0625_w19_qp_42 Q:3

Fig. 3.1 shows a gas contained in a cylinder enclosed by a piston.

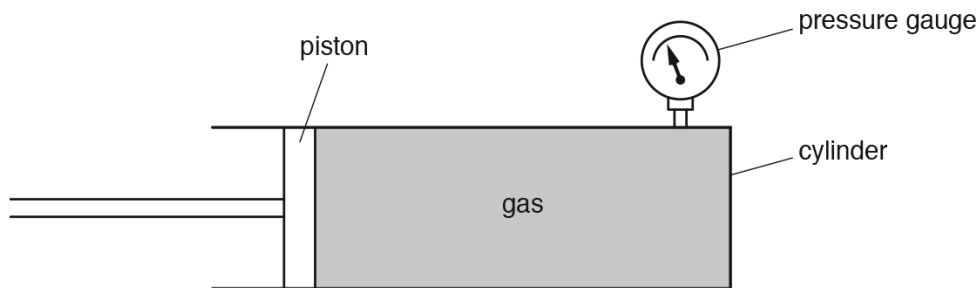


Fig. 3.1

- (a) Describe, in terms of momentum of the molecules, how a pressure is exerted on the walls of the cylinder.

.....
.....
.....
.....
..... [3]

- (b) The piston is pushed into the cylinder. The volume decreases from 820cm^3 to 330cm^3 . The pressure gauge measures the pressure after compression as 20000Pa . The temperature remains constant.

Calculate the value of the pressure before the gas was compressed.

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pressure = [3]

[Total: 6]

18.0625_w19_qp_43 Q:4

Solids have a fixed shape. Liquids adapt to the shape of their container. Gases fill their container.

Explain in terms of forces between molecules and arrangement of molecules, why solids, liquids and gases have these properties.

Solids

.....

.....

Liquids

.....

.....

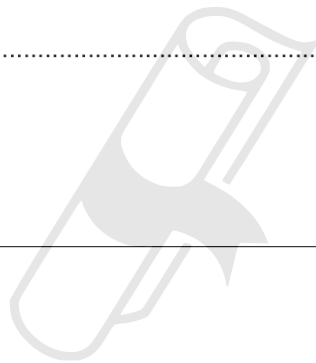
Gases

.....

.....

[6]

[Total: 6]



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2.1. KINETIC PARTICLE MODEL OF MATTER

19.0625_m18_qp_42 Q:5

(a) Fig. 5.1 shows the apparatus used to observe the motion of smoke particles that are in the air in a box.

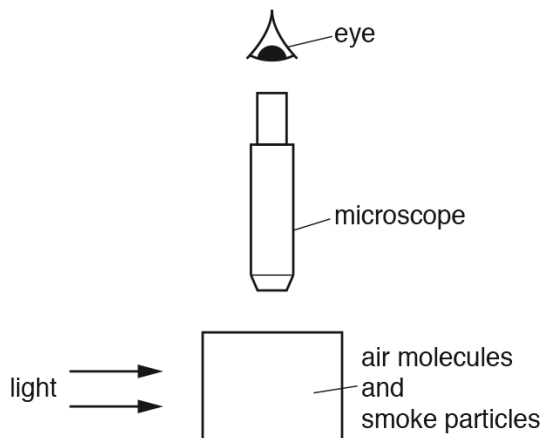


Fig. 5.1

Light from a lamp enters the box through a window in one side of the box. The smoke particles are observed using a microscope fixed above a window in the top of the box.

(i) The motion of a single smoke particle is observed through the microscope.

In the circle shown, sketch the path of this smoke particle.



[1]

(ii) Explain why the smoke particle follows the path that is observed.

.....
.....
.....
..... [3]

(b) A tennis player is practising by hitting a ball many times against a wall.

The ball hits the wall 20 times in 60s. The average change in momentum for each collision with the wall is 4.2 kg m/s .

Calculate the average force that the ball exerts on the wall.

average force = [3]

[Total: 7]

20.0625_s18_qp_41 Q:4

(a) Describe the movement of the molecules in

(i) a solid,

.....
..... [1]

(ii) a gas.

.....
..... [2]

(b) A closed box contains gas molecules.

Explain, in terms of momentum, how the molecules exert a pressure on the walls of the box.

.....
.....
.....
.....
.....
..... [4]

[Total: 7]

2.1. KINETIC PARTICLE MODEL OF MATTER

21.0625_s18_qp_42 Q:4

(a) Fig. 4.1 represents an atom.

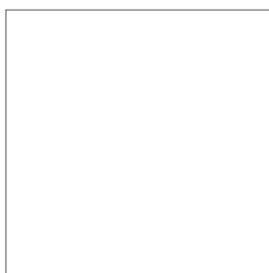


Fig. 4.1

Representing atoms by circles approximately the same size as in Fig. 4.1, sketch

(i) on Fig. 4.2, the arrangement of atoms in a crystalline solid, [1]

(ii) on Fig. 4.3, the arrangement of atoms in a gas. [1]



solid

Fig. 4.2



gas

Fig. 4.3

(b) (i) Describe the motion of the atoms in a solid.

..... [1]

(ii) A sculptor makes a statue from a block of crystalline rock using a cutting tool. Explain why he must apply a large force to the tool to remove a small piece of rock.

..... [2]

(c) A helium-filled balloon in the room of a house suddenly bursts.

State and explain, in terms of atoms, what happens to the helium from the balloon after the balloon has burst.

..... [2]

[Total: 7]

2.1. KINETIC PARTICLE MODEL OF MATTER

23.0625_s18_qp_43 Q:5

- (a) A microscope that produces a very high magnification is used to observe the Brownian motion of smoke particles in air.

Fig. 5.1(a) shows the apparatus used with the microscope. Fig. 5.1(b) represents the view through the microscope and shows one of the smoke particles being observed.

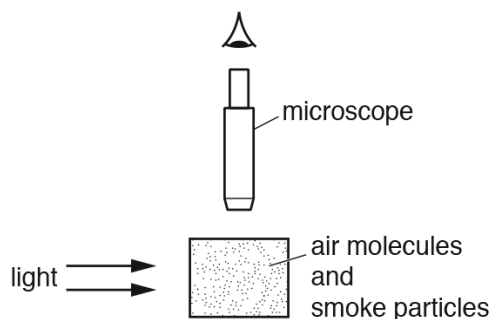


Fig. 5.1(a)

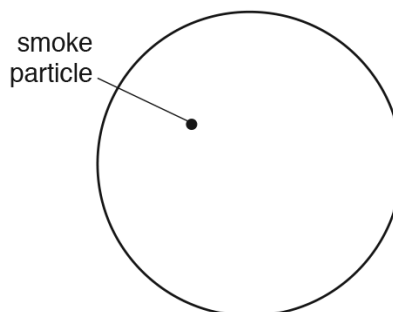


Fig. 5.1(b)

- (i) On Fig. 5.1(b), draw a possible path for the smoke particle. [2]
 (ii) Describe how air molecules cause the smoke particle to follow the observed path.

.....

 [2]

- (b) Fig. 5.2 shows a volume of gas in a cylinder.

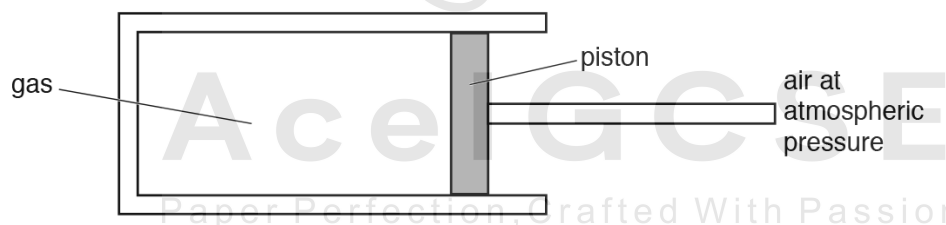


Fig. 5.2

The piston in the cylinder is free to move. The piston moves to the left when the temperature of the gas is decreased.

Explain, in terms of the molecules of the gas, why this happens.

.....

 [4]

[Total: 8]

24. 0625_s17_qp_42 Q: 4

A balloon contains a fixed mass of gas.

(a) Explain, in terms of the momentum of molecules, how the gas in the balloon exerts a pressure.

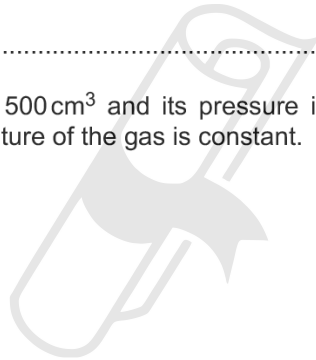
.....
.....
.....
.....[2]

(b) Explain, in terms of molecules, why the pressure of the gas increases when the volume of the balloon decreases. The temperature of the gas is constant.

.....
.....
.....
.....[2]

(c) The initial volume of the gas is 500 cm^3 and its pressure is $1.1 \times 10^5\text{ Pa}$. The volume is reduced to 200 cm^3 . The temperature of the gas is constant.

Calculate the new pressure.



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pressure =[2]

[Total: 6]

2.1. KINETIC PARTICLE MODEL OF MATTER

25.0625_s17_qp_43 Q:6

Fig. 6.1 shows a child releasing a balloon filled with helium.



Fig. 6.1

The pressure of the helium in the balloon keeps the balloon inflated.

(a) Explain how the particles of helium produce this pressure.

.....
.....
.....
.....[3]

(b) As the balloon travels upwards through the atmosphere, the volume of the helium increases. The temperature of the helium remains constant.

(i) State an equation that relates the volume of the helium to its pressure.

.....[1]

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- (ii) Fig. 6.2 shows how the air pressure in the atmosphere changes with the height above ground level.

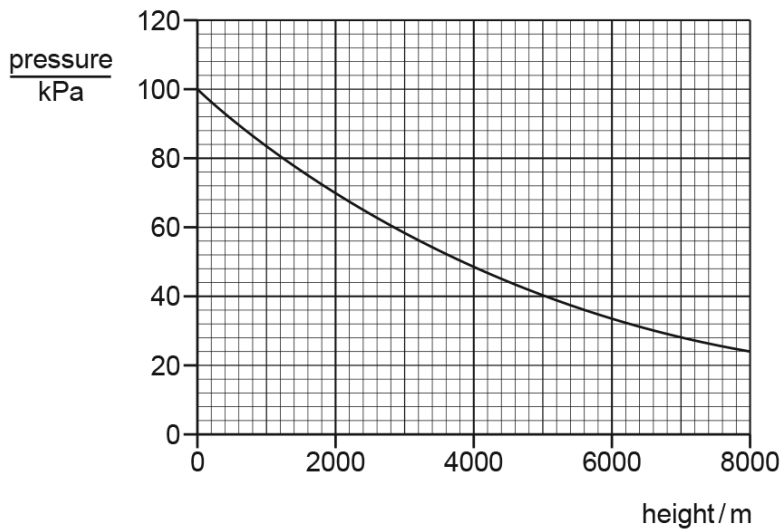


Fig. 6.2

- Using Fig. 6.2, determine the pressure at ground level. Give the unit.
 pressure = unit = [2]
- Using Fig. 6.2, determine the height at which the volume of the helium in the balloon is twice the volume at ground level.

height = [2]

[Total: 8]

2.1. KINETIC PARTICLE MODEL OF MATTER

26.0625_w17_qp_41 Q:4

Fig. 4.1 shows a balloon filled with helium that is used to lift measuring instruments to a great height above the Earth's surface.



Fig. 4.1

- (a) Explain, in terms of momentum, how the atoms of helium produce a force on the wall of the balloon.

.....
.....
.....
..... [3]

- (b) At ground level, the pressure of the helium in the balloon is 1.0×10^5 Pa. The volume occupied by the helium is 9.6 m^3 .

The balloon is released and it rises quickly through the atmosphere. The volume occupied by the helium increases, but the temperature of the helium may be assumed to stay constant.

- (i) Explain, in terms of the helium atoms in the balloon, why the pressure in the balloon is smaller than at ground level.

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- (ii) Calculate the pressure of the helium when it occupies a volume of 12 m^3 .

pressure = [2]

[Total: 7]

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- (a) The molecules of most liquids are, on average, slightly further apart than the molecules of a solid.

State **one** other difference between the molecular structures of a solid and a liquid.

.....
[1]

- (b) A glass tube passes through a stopper and into a glass flask. Fig. 4.1 shows that the flask is completely full of a liquid and that there is also some liquid in the tube.

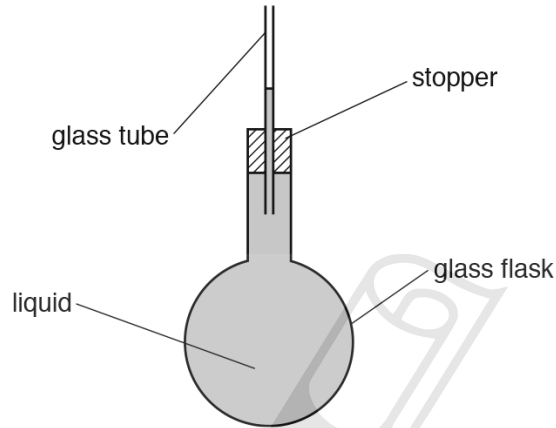


Fig. 4.1

The flask is immersed in a large beaker of very hot water. At first, the level of the liquid in the tube falls, but after a short time it rises.

- (i) Explain why, at first, the level of the liquid in the tube falls.

.....

[3]

- (ii) Explain why the liquid level in the tube stops falling and starts to rise.

.....

[2]

[Total: 6]