2. Thermal physics

2.1 Kinetic particle model of matter

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 Fig. 5.1 shows a metal box. The air in the box is at room temperature, 20 °C.
Air cannot leave or enter the box.

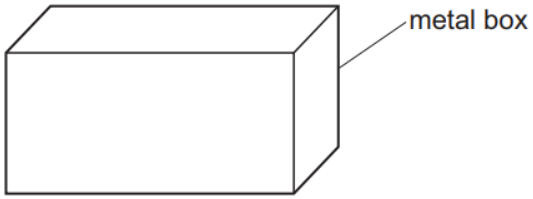

Fig. 5.1

(a) Describe the motion, separation and arrangement of the air particles in the metal box.

.....

.....

..... [3]

(b) A student puts the box in a freezer. The temperature of the air in the box decreases.

Describe the changes in the motion of the air particles in the box when the temperature decreases.

.....

..... [2]

[Total: 5]

2 A sealed glass bottle contains air.
The temperature of the air is 21 °C.

(a) Calculate the temperature of the air in kelvin.

temperature = ... K [2]

(b) The temperature of the air in the bottle decreases to 14 °C.
State and explain what happens to the pressure inside the bottle. Use your ideas about gas particles.

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..... [4]

[Total: 6]

3 **(a)** Describe the arrangement, separation and motion of gas particles.

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.....

.....

..... [3]

(b) Fig. 5.1 shows some gas in a container with a piston. The piston can move into the container.

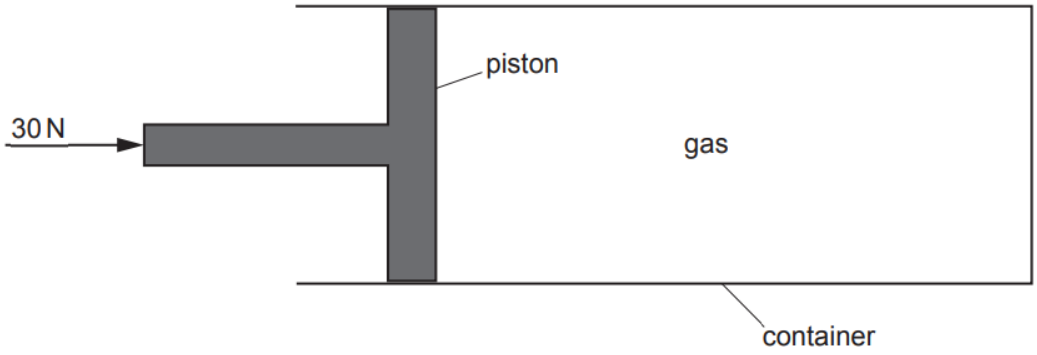

Fig. 5.1

(i) A force of 30 N pushes the piston into the container for a distance of 0.18 m.

Calculate the work done by the 30 N force.

work done = ... J [3]

(ii) When the piston moves into the container, the temperature of the gas does **not** change.

Describe and explain any change in the pressure on the walls of the container.

.....

.....

..... [2]

[Total: 8]

4 Fig. 5.1 shows a metal block at room temperature on a table.

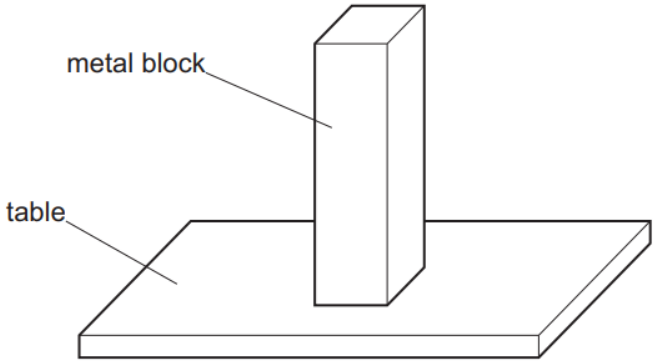

Fig. 5.1

(a) Describe the arrangement, separation and motion of the particles in the metal block.

.....

.....

.....

..... [3]

(b) **(i)** The temperature of the metal block decreases.

Describe any changes in the motion and separation of the particles in the metal block.

.....

..... [2]

(ii) A scientist cools the metal block until its temperature is close to absolute zero.

Describe the motion of the particles in the metal block.

.....

..... [1]

(c) The weight of the metal block is 26 N. The area of the metal block in contact with the table is 42 cm^2.

Calculate the pressure on the table due to the metal block.

pressure = ... N/cm^2 [3]

[Total: 9]

5 Fig. 3.1 represents the arrangement and separation of particles in a liquid. Each circle represents a particle.

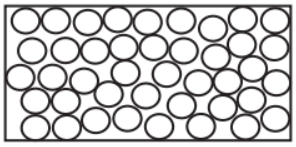

Fig. 3.1

(a) In the box in Fig. 3.2, draw at least **four** circles to show the arrangement and separation of particles in a **gas**.

Fig. 3.2

[2]

(b) Describe the arrangement, separation and motion of particles in a **solid**.

.....

.....

..... [3]

6 Fig. 5.1 represents some particles of a gas in a metal box. The arrows represent the directions of movement of the particles.

Fig. 5.1 (not to scale)

(a) Describe how the particles in Fig. 5.1 exert a pressure on the walls of the box.

.....

.....

..... [3]

(b) The number of gas particles in the box increases. The temperature of the gas does **not** change.

State and explain the effect, if any, on the pressure exerted by the gas particles on the walls of the box.

.....

.....

..... [2]

[Total: 5]

7 A student has a block of solid metal at room temperature.

(a) (i) Describe the arrangement, separation and motion of the particles in the solid metal.

.....

.....

.....

..... [3]

(ii) The student cools the block of metal in a freezer.

State the effect, if any, of cooling on the kinetic energy of the particles in the block of metal.

..... [1]

(b) (i) State the name of the temperature at which particles have the least kinetic energy.

..... [1]

(ii) State the value of temperature at which particles have the least kinetic energy. Include the unit.

..... [1]

(c) The metal block emits thermal radiation from its surface.

State **two** features of a surface that is a good emitter of thermal radiation.

1 .....

2 .....

[2]

[Total: 8]

8 **(b)** Some gas is trapped in a cylinder fitted with a moveable piston. Fig. 5.2 shows the arrangement.

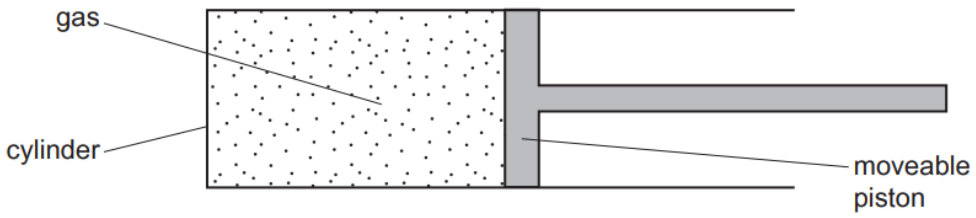

Fig. 5.2

(i) Describe how the gas exerts a pressure on the cylinder.

Use your ideas about molecules.

.....

..... [2]

(ii) The piston moves and increases the volume occupied by the gas. The temperature of the gas remains constant. Fig. 5.3 shows the new position of the piston.

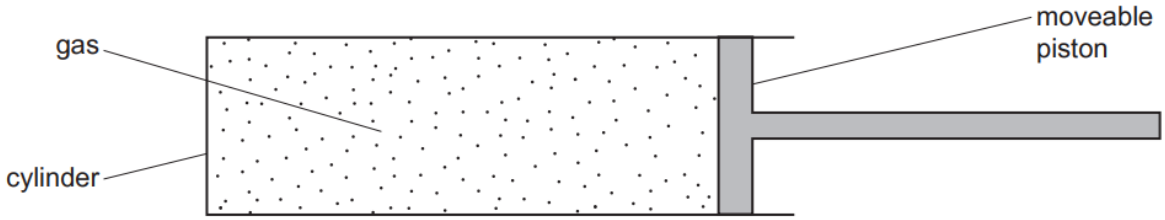

Fig. 5.3

State and explain what happens to the pressure of the gas on the cylinder.

.....

..... [2]

[Total: 8]

9 **(b)** Describe the molecular structure of the wax in terms of the arrangement, separation and motion of its molecules when it is a solid and when it is a gas.

solid wax .....

.....

wax as a gas .....

.....

[6]

10 **(c)** A student uses a microscope to view a small particle in the liquid. Fig. 5.2 shows the path of the particle.

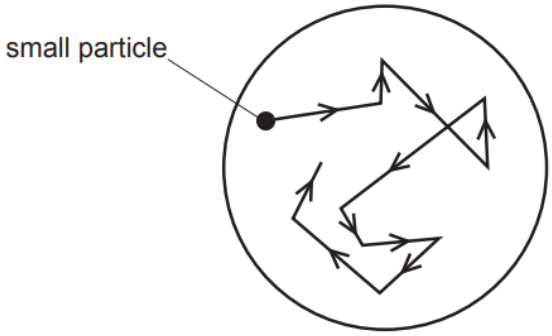

Fig. 5.2

(i) State the name given to the motion of the small particle.

..... [1]

(ii) Explain why the small particle moves as shown in Fig. 5.2.

.....

..... [2]

11 **(a)** A substance cools from 50 °C to 5.0 °C. Its melting point is 20 °C. The substance takes 30 minutes to cool from 50 °C to its melting point.

The substance takes a total time of 80 minutes to cool from 50 °C to 5.0 °C.

On Fig. 4.1, sketch a graph that shows how the temperature of the substance varies with time as it cools from 50 °C to 5.0 °C.

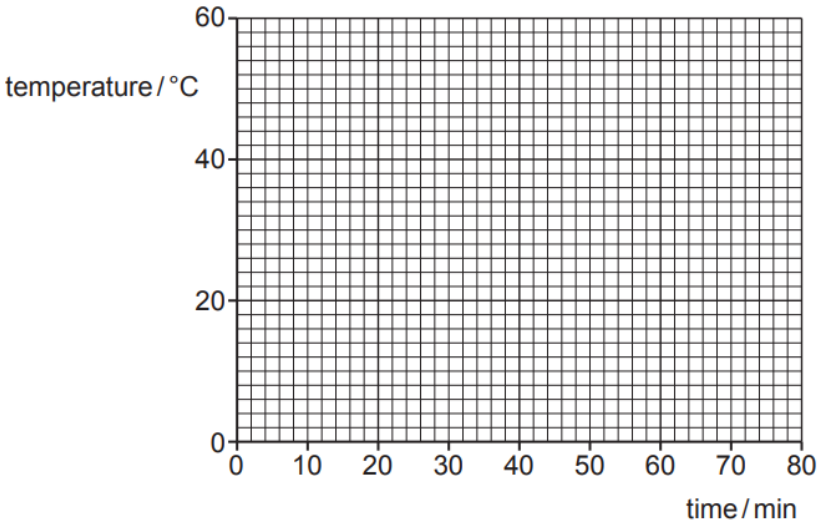

Fig. 4.1

[4]

(b) Describe the arrangement and motion of the molecules in the substance when they are in the solid state.

.....

.....

.....

..... [2]

[Total: 6]

12 Fig. 6.1 shows a smoke cell. The smoke cell contains air molecules and smoke particles. A student views the motion of the smoke particles in the smoke cell by using a microscope.

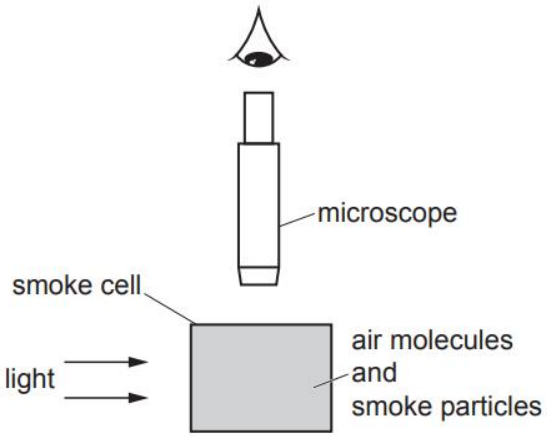

Fig. 6.1

Fig. 6.2 shows the path of one of the smoke particles.

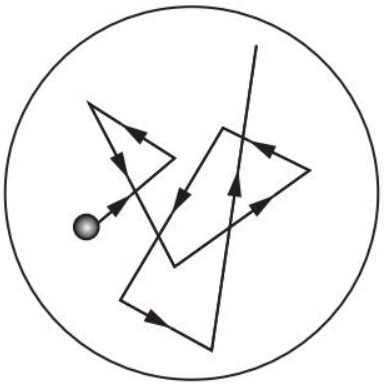

Fig. 6.2

(a) State the term used for the motion of the smoke particle.

..... [1]

(b) Explain the motion of the smoke particle in Fig. 6.2.

.....

.....

.....

..... [3]

[Total: 4]

13 **(a)** Fig. 6.1 represents three changes of state. Each pair of diagrams A, B and C shows the arrangement of molecules in a substance before and after it changes state.

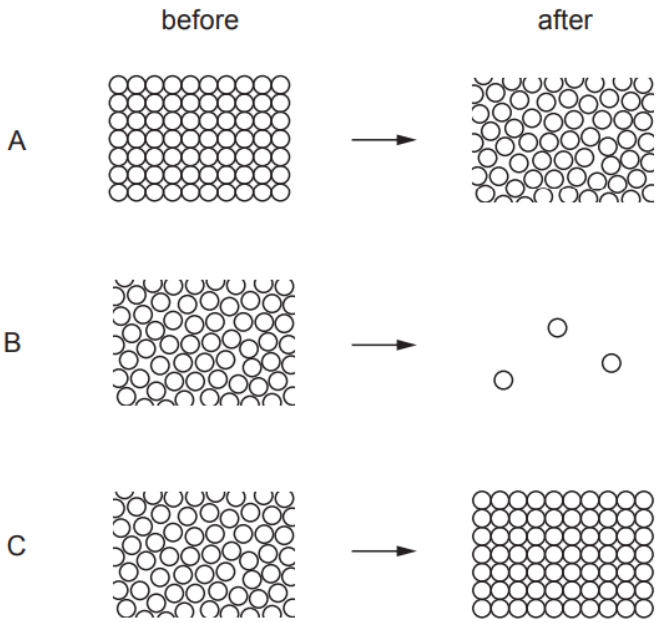

Fig. 6.1

Give the term used for each change of state.

A .....

B .....

C .....

[3]

14 A rigid container is filled with a gas.

(a) Describe the movement and arrangement of the gas molecules in the container.

.....

.....

..... [3]

(b) The gas in the container is heated. The volume of the gas does **not** change.

State and explain the change in pressure of the gas as the temperature of the gas increases. Use your ideas about molecules in your answer.

.....

.....

.....

..... [3]

[Total: 6]

15 Some gas molecules are in a box at room temperature.
Fig. 3.1 shows the position of some of the molecules and the direction of movement of each molecule.

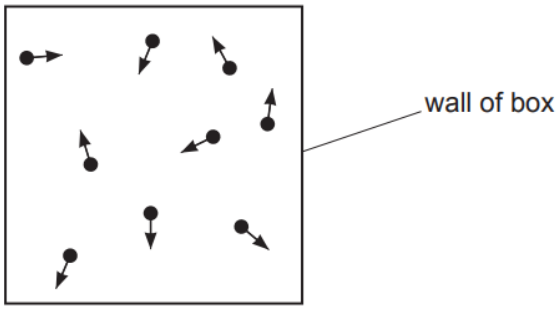

Fig. 3.1

(a) (i) Describe the movement of the gas molecules.

.....

.....

..... [2]

(ii) Describe how the molecules exert a pressure on the walls of the box.

.....

.....

.....

..... [2]

(b) The gas in Fig. 3.1 is cooled. The gas turns into a liquid then into a solid.

State how the average separation of molecules in the gas is different from the average separation of molecules in the solid.

.....

..... [1]

[Total: 5]

16 **(a)** Match each description with the correct state of matter in Table 4.1.

Write the correct letter in Table 4.1.

A – Molecules move around freely and are far apart from each other.

B – Molecules vibrate about fixed positions.

C – Molecules move around randomly and are close to each other.

Table 4.1

state of matter	description
solids	
liquids	
gases	

[2]

17 All matter is made up of atoms and molecules.

(a) Describe the arrangement, separation and motion of gas molecules.

arrangement .....

separation .....

motion .....

[3]

(b) The motion of smoke particles in air can be observed using a smoke cell and microscope. Fig. 7.1 shows the arrangement.

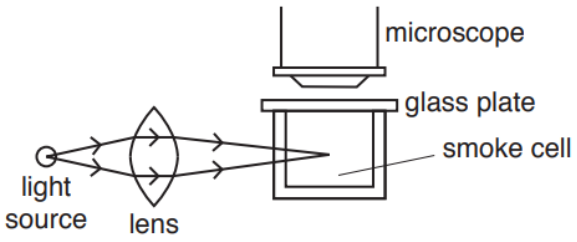

Fig. 7.1

Smoke is placed inside the glass smoke cell. Light enters from the side of the smoke cell.

A student looks through the microscope. She sees tiny spots of light moving. Each spot of light is a smoke particle.

Fig. 7.2 represents the path of a smoke particle seen in the eyepiece of the microscope.

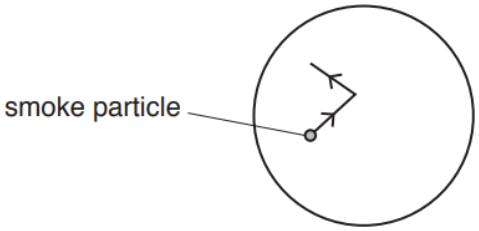

Fig. 7.2

(i) On Fig. 7.2, continue the path of the smoke particle. [2]

(ii) State the term used to describe the movement of the smoke particle.

..... [1]

[Total: 6]

18 **(a)** Solid, liquid and gas are three states of matter.

For each state of matter describe the arrangement of the molecules.

solid .....

.....

liquid .....

.....

gas .....

.....

[3]

(b) A liquid is spilt on a bench in a warm laboratory. After a short time, the liquid disappears.

(i) State the name of the process that causes the liquid to disappear.

..... [1]

(ii) The process in **(b)(i)** causes a cooling effect.

Explain why the cooling effect occurs. Use your ideas about molecules.

.....

.....

.....

.....

..... [3]

[Total: 7]

19 A student draws diagrams that represent three states of matter, as shown in Fig. 4.1.
Box B shows the arrangement of particles in a liquid.

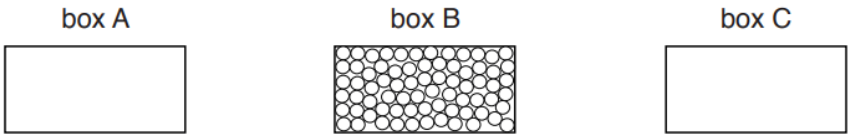

Fig. 4.1

(a) **(i)** In box A, draw the arrangement of particles in a solid. [1]

(ii) In box C, draw the arrangement of particles in a gas. [1]

(b) Write the correct term for each change of state below each arrow in Fig. 4.2.

solid ⟹ liquid gas ⟹ liquid

....

[2]

Fig. 4.2

(c) A wet beaker is in a warm room. After several hours the beaker is dry.

State and explain what happens to the water.

Use your ideas about molecules in your answer.

.....

.....

.....

.....

.....

.....[3]

[Total: 7]

20 **(a)** Fig. 4.1 shows a smoke cell. The cell contains smoke particles and air molecules. It is lit from the side. A student views the motion of smoke particles in the cell by using a microscope.

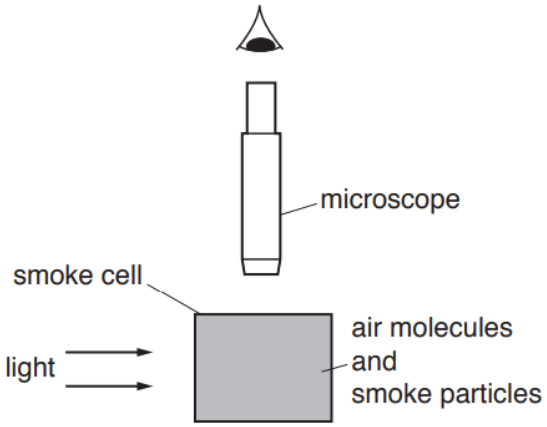

Fig. 4.1

Describe and explain what the student sees when viewing the smoke particles through the microscope.

.....

.....

.....

.....

.....

.....[4]

(b) Drops of water on a warm surface disappear after a short time. State the term used to describe this process. Explain the process, using your ideas about molecules.

name of process .....

explanation .....

.....

.....

[3]

[Total: 7]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

21 Fig. 4.1 shows a bottle part-filled with water. The air inside the bottle is at the same pressure as the air outside the bottle. The bottle and its contents are at room temperature.

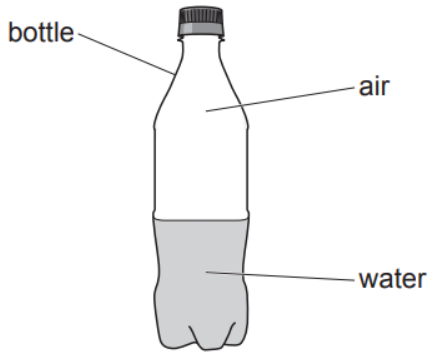

Fig. 4.1

(a) The temperature of the bottle and its contents are increased.

(i) Explain, in terms of particles, how the air pressure inside the bottle changes as the temperature increases.

.....

.....

.....

..... [3]

(ii) The lid is removed from the bottle.

State and explain how the air pressure inside the bottle changes.

statement .....

explanation .....

.....

[2]

22 A rubber balloon is inflated with helium and sealed so that no helium escapes.

The balloon is positioned immediately below the ceiling in a room.

Heaters are switched on and the temperature of the air in the room increases.

(a) When the heaters are first switched on, the temperature of the air immediately below the ceiling increases more quickly than the temperature of the air in the rest of the room.

Explain why this happens.

.....

.....

..... [2]

(b) The temperature of the helium in the balloon increases and as the rubber stretches, the volume occupied by the helium increases.

(i) State what happens to the motion of the helium particles as the temperature increases.

.....

..... [1]

(ii) As the rubber stretches and the volume of the helium increases, the pressure of the helium remains constant.

Explain, in terms of the particles of helium, how the pressure of the helium remains constant.

.....

.....

.....

..... [3]

[Total: 6]

23 **(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 350 cm^3 of gas at a pressure of 9.0×10^4 Pa. The gas is transferred to cylinder 2 and the pressure increases to 1.6×10^5 Pa. The temperature remains constant.

Calculate the volume of cylinder 2. **(extended only)**

volume = ... [3]

[Total: 9]

24 A quantity of gas is trapped by a piston in a cylinder with thin metal walls. The piston is free to move without friction within the cylinder.

Fig. 4.1 shows the cylinder and piston.

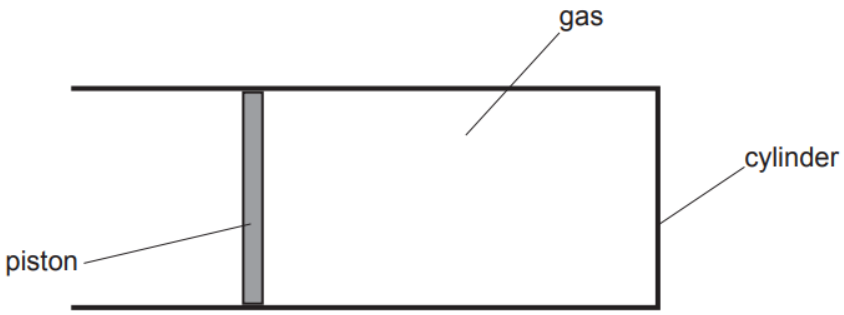

Fig. 4.1

The cylinder is placed inside a freezer.

(c) When the temperature reaches –18 °C, the pressure of the gas in the cylinder is still equal to that of the atmosphere.

Explain, in terms of the particles of the gas, how the pressure remains equal to its original value.

.....

.....

.....

.....

.....

..... [3]

(d) As the temperature of the metal cylinder decreases, the volume of the metal decreases. The decrease in the volume of the metal is much less than the decrease in the volume of the gas.

Explain, in terms of the particles of the metal, why the decrease in the volume of the metal is less than that of the gas. **(extended only)**

.....

.....

..... [2]

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

.....

.....

.....

..... [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 9.0×10^4 Pa. The volume of the container decreases by 70 cm^3 at constant temperature.

Calculate the new pressure of the gas. **(extended only)**

pressure = ... [3]

[Total: 8]

26 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 1.0×10^5 Pa.

(extended only)

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 1.4×10^5 Pa.

volume = ... [2]

(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]

[Total: 7]

27 A large test-tube contains a liquid at room temperature. An electric heater is immersed in the liquid and is switched on. Thermal energy is supplied to the liquid by the heater. The temperature of the liquid increases until it reaches its boiling point. The liquid then starts to change into gas.

(a) Describe, in terms of molecules and their motion, how a liquid differs from a gas.

.....

.....

.....

.....

..... [3]

(b) Describe what happens to molecules of the liquid as its temperature begins to increase.

.....

.....

..... [2]

28 **(a)** Describe the movement of the molecules in

(i) a solid,

.....

.....[1]

(ii) a gas.

.....

.....[2]

(b) A closed box contains gas molecules. **(extended only)**

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

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.....

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.....

.....

.....[4]

[Total: 7]