

States of matter

30 questions: 15 multiple choice, 15 structured.

1 Core Solids, liquids and gases [1]

Which row correctly describes the properties of a liquid?

	Has a fixed shape?	Has a fixed volume?	Flows easily?
A	yes	yes	no
B	no	no	yes
C	no	yes	yes
D	yes	no	no

2 Core Solids, liquids and gases [1]

In a gas, compared with a liquid, the particles are

- A closer together and move faster.
- B closer together and move slower.
- C further apart and move faster.
- D further apart and move slower.

3 Core Solids, liquids and gases [1]

Water vapour in the air forms droplets on the outside of a glass of cold lemonade on a warm day. What is the name of this change of state?

- A boiling
- B evaporating
- C freezing
- D condensing

4 Core Solids, liquids and gases

[1]

The particles of a pure substance are put in order of increasing average energy. Which order is correct?

- A gas < liquid < solid
 - B liquid < solid < gas
 - C solid < gas < liquid
 - D solid < liquid < gas
-

5 Core Solids, liquids and gases

[1]

A sealed, flexible balloon contains a fixed mass of air. The balloon is left in direct sunlight. Its temperature rises, while the pressure of the air inside stays roughly equal to the pressure outside. What happens to the volume of the balloon?

- A It decreases.
 - B It increases.
 - C It stays the same.
 - D It cannot be predicted.
-

6 Core Solids, liquids and gases

[1]

A student blocks the outlet of a bicycle pump with a finger, trapping a fixed mass of air inside at constant temperature. The student then pushes the pump handle in, decreasing the volume of the trapped air. What happens to the pressure of the trapped air?

- A It increases.
 - B It decreases.
 - C It stays the same.
 - D It becomes zero.
-

7 Supplement Solids, liquids and gases

[1]

Which statement best explains, in terms of kinetic particle theory, why a solid melts when it is heated?

- A The particles lose energy and move closer together.
- B The particles gain energy and spread far apart, moving randomly at high speed.
- C The particles gain energy, vibrate more, and eventually break free from their fixed positions.
- D The particles stop moving completely.

8**Supplement**

Solids, liquids and gases

[1]

Pure solid stearic acid is heated steadily and its temperature is recorded every minute.

Time / min	0	1	2	3	4	5	6
Temperature / °C	40	50	60	69	69	69	75

During which time interval is the stearic acid melting?

- A 0–1 minutes
- B 3–5 minutes
- C 1–2 minutes
- D 5–6 minutes

9**Supplement**

Solids, liquids and gases

[1]

A rigid, sealed metal container holds a fixed mass of gas. The container is heated, and its volume cannot change. Which statement correctly explains, in terms of kinetic particle theory, why the pressure of the gas increases?

- A The particles move faster and collide with the container walls more often and with greater force.
- B The particles become larger as they are heated.
- C The number of particles in the container increases.
- D The particles move closer together, increasing the density of the gas.

10**Core**

Solids, liquids and gases

[1]

Which statement correctly distinguishes evaporation from boiling?

- A Evaporation only happens at the boiling point; boiling can happen at any temperature.
- B Evaporation happens only at the surface of a liquid and can occur below the boiling point; boiling happens throughout the liquid at a fixed temperature.
- C Evaporation happens throughout the liquid; boiling happens only at the surface.
- D There is no difference between evaporation and boiling.

A football feels harder after it has been kicked around on a cold morning and has warmed up, even though no more air has been pumped into it. Which explanation, in terms of kinetic particle theory, best accounts for this?

- A The air particles move faster as their temperature rises, so they collide with the inside of the ball more often and with greater force, increasing the pressure.
- B The air particles inside have increased in size.
- C More air particles have entered the ball.
- D The rubber of the ball contracts, squeezing the air into a smaller volume.

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A pure sample of ice is heated steadily from -20°C until it becomes steam. Its temperature is recorded every 2 minutes.

Time / min	0	2	4	6	8	10	12	14	16	18	20	22
Temperature / $^{\circ}\text{C}$	-20	-10	0	0	0	20	40	60	80	100	100	100

- (a) Use the table to state the melting point and the boiling point of the substance.

[2]

- (b) Name the change of state that is happening between 4 and 8 minutes, and the change of state that is happening between 18 and 22 minutes.

[2]

- (c) Explain, in terms of kinetic particle theory, why the temperature does not rise between 4 and 8 minutes even though the substance is being heated continuously.

[2]

A sealed box contains a sample of a pure substance, R, at room temperature. Substance R has no fixed shape, flows to fill the bottom of any container it is put in, and has a fixed volume.

- (a) State the physical state of substance R at room temperature. [1]

- (b) Describe the arrangement, separation and motion of the particles in substance R that give it these properties. [4]

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A weather balloon is released from the ground. It is partly inflated with helium gas before launch, and it rises through the atmosphere. The table shows how atmospheric pressure changes with altitude.

Altitude / km	0	5	10	15	20
Atmospheric pressure / kPa	100	54	26	12	6

Assume that the pressure of the gas inside the balloon always matches the atmospheric pressure outside, and that the temperature of the gas does not change.

- (a) State how the atmospheric pressure changes as altitude increases. [1]

- (b) Describe how the volume of gas inside the balloon changes as it rises from the ground to an altitude of 20 km. [2]

- (c) Suggest why weather balloons are launched only partly inflated, rather than fully inflated. [2]

An aerosol deodorant can is labelled "Pressurised container: do not heat above 50 °C." The can is accidentally left on a shelf close to a radiator and warms up.

- (a) Explain, in terms of kinetic particle theory, what happens to the movement of the gas particles inside the can as it is heated. [3]

- (b) Explain why this causes the pressure of the gas inside the can to increase. [2]

- (c) Explain why the can could burst if it is heated too much. [2]

A small block of solid paraffin wax is heated gently in a boiling tube standing in a water bath. The wax melts completely. Heating is then continued until a little of the liquid wax evaporates.

- (a) Name the two changes of state described above, in the order in which they happen. [2]

- (b) Describe how the separation and arrangement of the wax particles change as the solid wax melts into a liquid. [3]

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A scuba diver's air cylinder holds a large mass of compressed air in a small, rigid volume, at a very high pressure.

- (a) Explain, in terms of kinetic particle theory, why the pressure of the air inside the cylinder is so high. [3]

- (b) The diver breathes in some air from the cylinder. Once in the diver's lungs, this air is at a much lower pressure than the pressure inside the cylinder. Explain what happens to the volume that this fixed mass of air now occupies. [2]

- (c) Explain, in terms of the volume of air in the lungs, why divers are trained to breathe out steadily and never hold their breath while swimming upward towards the surface. [2]

On a warm, windy day, washing hung on a line becomes dry after a few hours, even though the air temperature is well below 100 °C. Later, water is boiled in a kettle to make a hot drink.

- (a) State one similarity between evaporation and boiling. [1]

- (b) Describe two differences between evaporation and boiling, in terms of temperature and where in the liquid it occurs. [3]

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A technician examines three unlabelled sealed containers, A, B and C, each holding a different pure substance at room temperature. The technician records these observations.

Container	Keeps its own shape?	Can be poured?	Easily compressed?
A	yes	no	no
B	no	yes	no
C	no	yes	yes

- (a) Identify the physical state of the substance in each container, A, B and C.

[3]

- (b) For container C, describe the arrangement and the motion of its particles that explain why it can be easily compressed.

[2]

A beaker of liquid water at room temperature is placed in a freezer. After several hours, all of the water has turned to solid ice.

- (a) Name this change of state. [1]

- (b) Explain, in terms of kinetic particle theory, what happens to the arrangement and motion of the water particles as freezing takes place. [3]

- (c) While the water is freezing, its temperature stays at 0°C , even though the freezer is continuously removing energy from it. Explain why the temperature does not fall during this time. [2]

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Core

Solids, liquids and gases

[4]

A student traps a fixed mass of air inside a sealed gas syringe. The temperature is kept constant.

- (a) The student pushes the plunger in. State what happens to the volume of the trapped air. [1]

- (b) State what happens to the pressure of the trapped air as the plunger is pushed in. [1]

- (c) The student then releases the plunger so that it is free to move, returns the trapped air to its original volume, and keeps the pressure constant by letting the plunger move freely while gently warming the air. State what happens to the volume of the trapped air as it warms up, and give a reason for your answer. [2]

A sample of molten lead is allowed to cool. Its temperature is recorded every 2 minutes.

Time / min	0	2	4	6	8	10	12	14
Temperature / °C	400	360	327	327	327	300	260	220

- (a) Use the table to state the freezing point of lead.

[1]

- (b) State what is happening to the lead, in terms of change of state, between 4 and 8 minutes.

[1]

- (c) Explain, in terms of kinetic particle theory, why the temperature of the lead does not fall between 4 and 8 minutes, even though the lead continues to lose energy to its surroundings during this time.

[3]

23**Core**

Diffusion

[1]

A bottle of perfume is opened in the corner of a room. After a few minutes, its scent can be detected on the other side of the room, even though there is no draught or fan. What is the name of this process?

- A osmosis
 - B evaporation
 - C diffusion
 - D convection
-

24**Core**

Diffusion

[1]

Fresh paint is applied to a wall in a room with the windows closed. Over the next hour, the smell of the paint fumes becomes noticeable throughout the whole room. Which statement correctly explains this using kinetic particle theory?

- A Paint fume particles are pushed through the air by wind currents created by people walking past.
 - B Paint fume particles are heavier than air particles, so they sink and spread along the floor.
 - C Paint fume particles only move once someone opens a door to let air in.
 - D Paint fume particles move randomly and continuously in all directions, gradually spreading from a region of higher concentration to a region of lower concentration.
-

25**Supplement**

Diffusion

[1]

Ammonia gas, NH_3 , and chlorine gas, Cl_2 , are released at the same time from two separate points, and allowed to diffuse through still air at the same temperature. (Ar: H = 1; N = 14; Cl = 35.5)

Which gas diffuses faster, and why?

- A Ammonia, because it has the smaller relative molecular mass.
- B Chlorine, because it has the larger relative molecular mass.
- C Ammonia, because it has the larger relative molecular mass.
- D Chlorine, because it has the smaller relative molecular mass.

26**Supplement**

Diffusion

[1]

Two gases, X and Y, are at the same temperature. Gas X has a smaller relative molecular mass than gas Y. Which statement correctly explains why gas X diffuses faster than gas Y?

- A Gas X has stronger forces of attraction between its particles.
 - B At the same temperature, particles of gas X and gas Y have the same average kinetic energy, so the lighter particles of gas X must move faster on average.
 - C Gas X has fewer particles in the same volume than gas Y.
 - D Gas X particles are smaller in physical size, so they occupy less space and diffuse instantly.
-

27**Core**

Diffusion

[5]

A small amount of orange bromine liquid is placed in a sealed gas jar and allowed to evaporate completely, forming orange bromine gas at the bottom of the jar. A second, empty gas jar is placed mouth-to-mouth on top of it, separated by a glass cover slip. The cover slip is then removed.

- (a) Describe what would be observed in the two gas jars over the next few minutes. [2]

- (b) Explain this observation in terms of kinetic particle theory. [3]

A single small crystal of purple potassium manganate(VII) is dropped gently into a beaker of cold water. The beaker is left undisturbed, without stirring, for one hour.

- (a) Describe what would be observed in the beaker over this hour. [2]

- (b) Explain this observation in terms of kinetic particle theory. [2]

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A horizontal glass tube, 100 cm long, is sealed at both ends with cotton wool plugs. Concentrated ammonia solution is added to the cotton wool at one end, releasing ammonia gas, NH_3 . Concentrated hydrochloric acid is added to the cotton wool at the other end, releasing hydrogen chloride gas, HCl . The two gases diffuse along the tube and react where they meet, forming a white ring of solid ammonium chloride, NH_4Cl . (Ar: H = 1; N = 14; Cl = 35.5)

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- (a) Calculate the relative molecular mass, M_r , of ammonia, NH_3 , and of hydrogen chloride, HCl . [2]

- (b) State which of the two gases has the smaller M_r . [1]

- (c) Predict, giving a reason, whether the white ring will form nearer the ammonia end or the hydrogen chloride end of the tube. [2]

- (d) Explain, in terms of kinetic particle theory, why a gas with a smaller M_r diffuses faster than a gas with a larger M_r , at the same temperature. [2]

Four gases are released, one at a time, from the same point in a large, still room. The time taken for each gas to be detected by a sensor 2 m away is recorded.

Gas	Relative molecular mass, M_r	Time to detect / s
Hydrogen	2	40
Methane	16	110
Oxygen	32	155
Sulfur dioxide	64	220

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- (a) Describe the relationship shown by the table between relative molecular mass and the time taken to detect the gas. [2]

- (b) Chlorine gas has a relative molecular mass of 71. Predict, with a reason, how the time taken to detect chlorine would compare with the time taken to detect sulfur dioxide. [2]

- (c) Explain, in terms of kinetic particle theory, why gases with a larger relative molecular mass diffuse more slowly than gases with a smaller relative molecular mass, at the same temperature. [2]
