IGCSE CHEMISTRY • EXERCISE SHEET

1.1 Solids, liquids and gases

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS particles 粒子 • pressure 压强 • solid 固体 • liquid 液体 • volume 体积

Objective

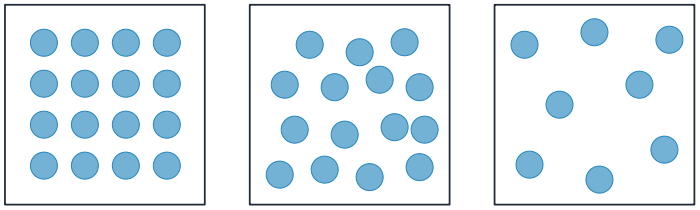
Build the skills to answer exam questions on **solids, liquids and gases** 固液气 — their properties, the particle picture, **changes of state** 状态变化, and gas behaviour.

You must be able to:

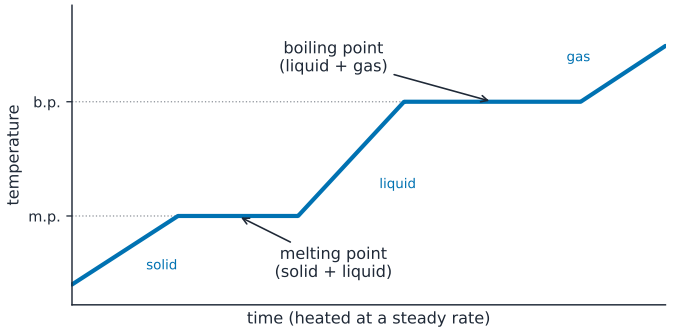
- describe the arrangement, separation and motion of particles in each state
- name the changes of state and explain them with the particle theory
- explain why temperature is constant during melting/boiling, and gas behaviour

1 Worked examples

■ Particles and changes of state



Packed and regular in a solid, close and random in a liquid, far apart in a gas



plateau: energy used as latent heat (bonds break) — temperature stays constant

Temperature stays constant while forces of attraction are broken (melting, boiling)

- **changes:** melting, freezing, evaporation, boiling, condensation (and sublimation).
- heating a gas at fixed volume raises the pressure (faster, harder, more frequent collisions).

■ The three states, and the two experiments that prove particles move

	arrangement	movement	forces between particles
solid 固体	regular, closely packed, touching	vibrate about fixed positions	strong
liquid 液体	close together, irregular	move around each other	weaker
gas 气体	far apart, random	move quickly in all directions	very weak or none

That table answers most questions on its own: a gas is easily compressed because of the space between its particles; a solid keeps its shape because its particles cannot change places; a liquid takes the shape of its container but keeps a fixed volume.

The changes of state, with the direction of energy: **melting** 熔化 solid→liquid and **boiling** 沸腾 liquid→gas both take energy IN, to overcome the forces between particles. **Condensing** 冷凝 gas→liquid and **freezing** 凝固 liquid→solid both give energy OUT. **Sublimation** 升华 goes straight from solid to gas.

Diffusion 扩散 is the spreading of a substance from a region of higher concentration to a region of lower concentration, caused by the random movement of the particles. Two rules explain every diffusion question:

- diffusion is **faster at a higher temperature**, because the particles have more

kinetic energy and move faster;

- diffusion is **faster for a lighter particle** — at the same temperature a molecule with a smaller relative molecular mass moves faster.

Worked example (the classic tube experiment). Cotton wool soaked in concentrated ammonia is put in one end of a long tube and cotton wool soaked in concentrated hydrochloric acid in the other. A white ring of ammonium chloride forms nearer the acid end. Explain.

1. Both liquids evaporate and their gas particles diffuse along the tube.
2. Ammonia, $M_r = 17$, is lighter than hydrogen chloride, $M_r = 36.5$.
3. The lighter ammonia molecules move faster, so they travel further before the gases meet.
4. The ring therefore forms nearer the hydrogen chloride end.

2 Practice

2.1 Name the change of state from gas to liquid. [1]

2.2 Describe the arrangement and motion of particles in a liquid. [2]

2.3 Explain, in terms of particles, why a gas can be compressed but a liquid cannot. [2]

2.4 Name the change of state from solid directly to gas, and state whether energy is taken in or given out. [2]

2.5 Explain why a smell spreads through a room faster on a hot day. [2]

3 Exam-style questions

3.1 Which property is true for a gas but not a liquid? [1]

- **A** it flows
- **B** it has a fixed volume
- **C** it is easily compressed
- **D** it has a fixed shape

3.2 A solid is heated until it melts and then boils.

(a) Explain, using the particle theory, why the temperature stays constant while the solid melts. [2]

(b) Explain why a gas can be compressed but a liquid cannot. [2]

3.3 A fixed mass of gas in a sealed rigid container is heated. Explain why its pressure rises. [3]

3.4 A long glass tube has cotton wool soaked in concentrated ammonia solution at one end and cotton wool soaked in concentrated hydrochloric acid at the other. After a few minutes a white ring forms inside the tube.

(a) Name the process by which the gases travel along the tube, and define it. [2]

(b) The white ring forms nearer the hydrochloric acid end. Explain why. [3]

(c) Predict and explain the effect of warming the whole tube. [2]

(d) Describe the arrangement and movement of the particles in the ammonia gas, and contrast them with the particles in the solid white ring. [4]

(e) The white solid is ammonium chloride. State the change of state that occurred when it formed from two gases, and state whether energy was taken in or given out. [2]

Solutions

2.1 condensation.

2.2 particles are close together, in a random arrangement; they move and slide past each other.

2.3 In a gas the particles are far apart with large spaces between them, so they can be pushed closer together; in a liquid the particles are already touching, so there is almost no space to remove.

2.4 Sublimation; energy is taken in.

2.5 The particles have more kinetic energy at a higher temperature and move faster, so they diffuse and spread through the room more quickly.

3.1 C. A gas is easily compressed; a liquid is not.

3.2 (a) the energy goes into breaking the forces of attraction between particles, not into making them move faster; so the temperature does not rise while melting.
(b) a gas has particles far apart with space between them, so it can be squeezed; a liquid's particles are already close together with almost no space.

3.3 heating gives the particles more kinetic energy, so they move faster; they hit the walls harder and more often; in a fixed volume this means the pressure rises.

3.4 (a) Diffusion; the spreading of particles from a region of higher concentration to a region of lower concentration because of their random movement.
(b) Ammonia has a relative molecular mass of 17 and hydrogen chloride 36.5, so ammonia molecules are lighter; at the same temperature the lighter molecules move faster; the ammonia therefore travels further along the tube before the two gases meet, so the ring forms nearer the acid end.
(c) The ring would form sooner, because the particles gain kinetic energy and diffuse faster at the higher temperature.
(d) Ammonia gas: the particles are far apart and randomly arranged, and move quickly in all directions. The solid ring: the particles are close together in a regular arrangement, and only vibrate about fixed positions.
(e) The gases changed to a solid, which is deposition or sublimation in reverse; energy was given out.