**Week 8**

# IGCSE Physics

Homework bundle for this week

本周作业合集

exercises.lol

## Contents 目录

IGCSE Physics Name: ____________ Score: ______

1. In which state are the particles far apart, fast, and moving in random directions?
   - ☐ gas
   - ☐ solid
   - ☐ liquid
   - ☐ they are the same in all states
2. For the same rise in temperature, which expands the most?
   - ☐ a gas
   - ☐ a liquid
   - ☐ a solid
   - ☐ they all expand by the same amount
3. While ice is melting into water, what happens to the temperature?
   - ☐ it stays the same until all the ice has melted
   - ☐ it rises steadily
   - ☐ it falls steadily
   - ☐ it rises then falls
4. Why are metals such good conductors of thermal energy?
   - ☐ they have free electrons that carry energy quickly
   - ☐ they are shiny
   - ☐ they are heavy
   - ☐ they contain trapped air
5. Temperature is a measure of:
   - ☐ the average kinetic energy of the particles
   - ☐ the total number of particles
   - ☐ the mass of the object
   - ☐ the colour of the object
6. Convert 27 °C to kelvin.

   ____________ K

7. How much energy is needed to heat 2.0 kg of water by 10 °C? (Use $c = 4200$ J per kg per °C.)

   ________________ J

8. Evaporation can happen below the boiling point.

   ☐ True ☐ False

9. Convection can happen in a solid.

   ☐ True ☐ False

10. A gas has a volume of 200 $cm^3$ at 100 kPa. It is squeezed to 100 $cm^3$ at constant temperature. What is the new pressure, in kPa?

    ________________ kPa

IGCSE Physics

1. **gas**

   Gas particles are far apart and move quickly in random directions, filling the container. Solids only vibrate; liquids slide past each other.

2. **a gas**

   Gases expand the most, then liquids, then solids (whose particles are held most tightly).

3. **it stays the same until all the ice has melted**

   During a change of state the energy goes into breaking the forces between particles, so the temperature stays constant until the change is complete.

4. **they have free electrons that carry energy quickly**

   Metals have free (delocalised) electrons that move through the metal and carry energy rapidly from the hot end to the cold end.

5. **the average kinetic energy of the particles**

   Hotter means the particles move faster, so temperature measures their average kinetic energy.

6. **300 K**

   $T = \theta + 273 = 27 + 273 = 300$ K.

7. **84000 J**

   $\Delta E = mc\,\Delta\theta = 2.0 \times 4200 \times 10 = 84\,000$ J.

8. **True**

   Evaporation happens at the surface at any temperature — the fastest surface particles escape. Boiling happens throughout the liquid at the boiling point.

9. **False**

   Convection needs particles to move from place to place, so it only happens in liquids and gases — not solids.

10. **200 kPa**

    $pV$ is constant: $100 \times 200 = p \times 100$, so $p = 200$ kPa. Halving the volume doubles the pressure.

IGCSE PHYSICS • EXERCISE SHEET

# 2.1 Kinetic particle model of matter

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

**KEY WORDS** brownian motion 布朗运动 • solid 固体 • liquid 液体 • particle 粒子 • gas 气体

## Objective

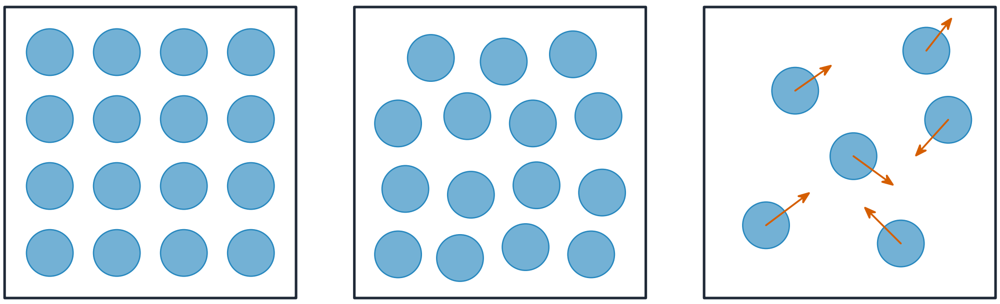
Build the skills to answer exam questions on the **kinetic particle model** 分子动理论 — the three states, **gas pressure** 气体压强, $pV$ = constant, and **Brownian motion** 布朗运动.

**You must be able to:**

- describe the particle arrangement and motion in solids, liquids, gases
- explain gas pressure and use $p_1V_1 = p_2V_2$ (constant temperature)
- describe Brownian motion as evidence for the particle model

## 1 Worked examples

### States and gas laws

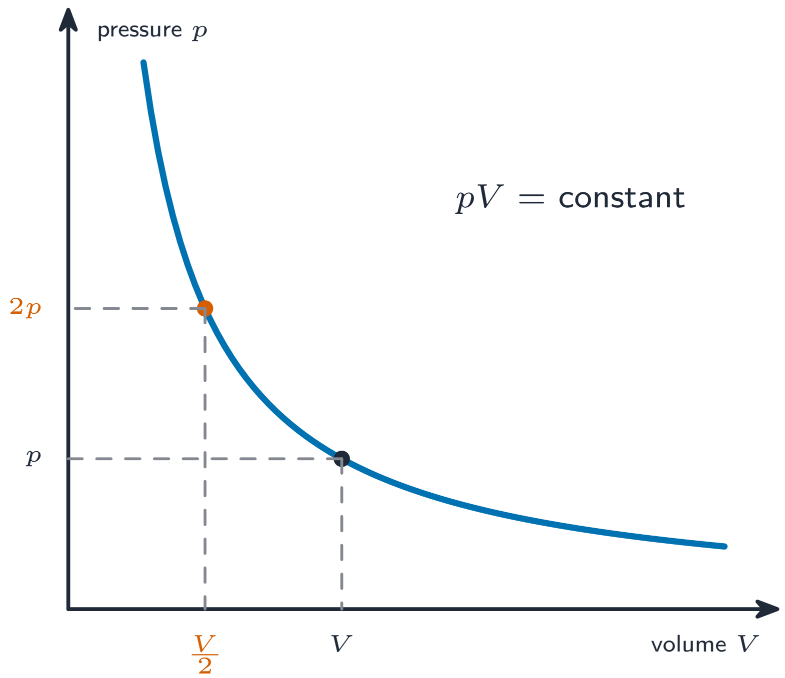


**solid**
fixed pattern,
vibrate in place

**liquid**
close, no pattern,
slide past

**gas**
far apart,
fast and random

*Solid: fixed and ordered; liquid: close but disordered; gas: far apart and fast*




*At constant temperature $pV$ is constant — halve $V$ and $p$ doubles*

200 **cm**$^3$ **at** 100 **kPa squeezed to** 50 **cm**$^3$**:** $100 \times 200 = p_2 \times 50 \Rightarrow p_2 = 400$ kPa.

## 2 Practice

**2.1** Describe the arrangement of particles in a solid. [1]

**2.2** A gas of volume 300 cm$^3$ at 120 kPa is compressed to 100 cm$^3$ at constant temperature. Find the new pressure. [2]

## 3 Exam-style questions

**3.1** Gas pressure on the container walls is caused by: [1]

- **A** particles vibrating in fixed positions
- **B** particles colliding with the walls
- **C** the gas expanding
- **D** the walls heating up

**3.2** A fixed mass of gas at constant temperature has $p_1 = 150$ kPa and $V_1 = 400$ cm$^3$.

(a) Find the volume when the pressure is increased to 250 kPa. [3]

(b) Explain, using the particle model, why the pressure rises as the volume falls. [2]

**3.3** Explain how Brownian motion provides evidence for the kinetic particle model. [2]

## Solutions

**2.1** particles are close together in a fixed, regular pattern, vibrating about fixed positions.

**2.2** $120 \times 300 = p_2 \times 100 \Rightarrow p_2 = 360$ kPa.

**3.1 B**. Pressure comes from particles colliding with the walls.

**3.2** (a) $p_1V_1 = p_2V_2$: $150 \times 400 = 250 \times V_2$; $V_2 = \dfrac{60000}{250}$; $= 240$ cm$^3$.
(b) in a smaller volume the particles hit each unit of wall area more often, so the pressure increases.

**3.3** the visible specks (e.g. smoke) move in a random, jerky way; this is because they are struck by fast, invisible air particles — showing matter is made of moving particles.

**9** Which statement correctly describes a change of state?

**A** A gas condenses to form a liquid.

**B** A liquid melts to form a solid.

**C** A solid condenses to form a liquid.

**D** A solid boils to form a gas.

**12** When pollen grains in water are viewed through a microscope, they are seen to be in continuous, rapid, random motion.

What causes a pollen grain to move in this way?

**A** convection currents in the water

**B** bombardment by a single molecule of water

**C** uneven bombardment on different sides by water molecules

**D** collision with another pollen grain

**14** Matter consists of very small particles in a continual state of motion.

Which row describes the behaviour of particles in a liquid?

| | force between particles | motion of particles |
|---|---|---|
| **A** | strong | move randomly at high speed |
| **B** | strong | vibrate, but change positions |
| **C** | weak | vibrate in fixed positions |
| **D** | weak | move randomly at high speed |

**3** **(a)** A car has a weight of 13 000 N. The car is supported by 4 tyres. The area of each tyre in contact with the road is $0.016\,m^2$.

**(i)** Calculate the pressure on the road due to the weight of the car.

pressure = ........................................................ [2]

**(ii)** Explain, in terms of particles, why the air pressure in the tyres increases when the car travels along the road.

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**(b)** A gas cylinder contains helium gas at a pressure of $2.0 \times 10^6$ Pa. A volume of $0.026\,m^3$ of the compressed gas is released from the cylinder into balloons. Each balloon contains $0.015\,m^3$ of helium at atmospheric pressure ($1.0 \times 10^5$ Pa). The temperature remains constant.

Calculate the maximum number of balloons that can be filled.

maximum number of balloons = ........................................................ [3]

[Total: 9]

**4** Fig. 4.1 shows a metal pan on an electric hotplate. The pan contains 200 $cm^3$ of water.

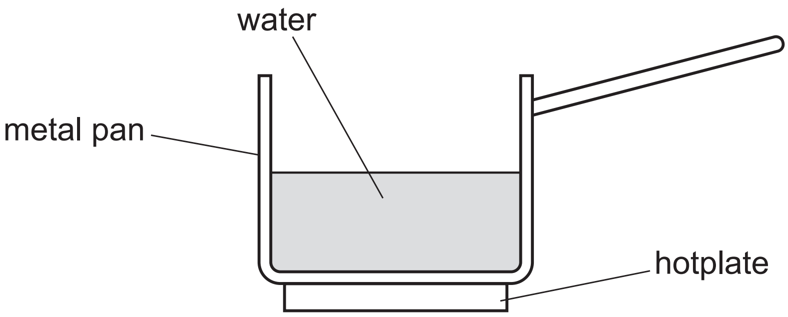


**Fig. 4.1**

The pan is heated. The temperature of the water in the pan increases.

**(a)** Thermal energy is transferred through the metal pan by conduction.

State and explain the **two** ways that thermal energy is conducted in a metal.

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

**(b) (i)** The water boils and leaves the liquid as a gas.

Explain, in terms of forces and distances between particles, why the gas occupies a much greater volume than it does as a liquid.

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

**(ii)** State **two** ways in which boiling differs from evaporation.

1 ......................................................................................................................................

2 ......................................................................................................................................

[2]

**(c)** The water is replaced with $200\,cm^3$ of milk.

The initial temperature of the milk is 20.0 °C. The boiling point of milk is 95.0 °C.

The milk starts to boil when 60 700 J of thermal energy has been transferred to it. The density of milk is $1.03\,g/cm^3$.

Calculate the value of the specific heat capacity of milk. Give your answer to 3 significant figures.

specific heat capacity = .......................................................... [4]

[Total: 11]

# 2.2 Thermal properties and temperature

Name: ______________ Class: __________ Date: ____________ **Total: 26 marks**

**KEY WORDS** specific heat capacity 比热容 • evaporation 蒸发 • thermal expansion 热膨胀 • thermal properties 热学性质 • boiling 沸腾 • specific heat capacity 比热容 • evaporation 蒸发 • thermal expansion 热膨胀 • thermal properties 热学性质 • melting 熔化

## Objective

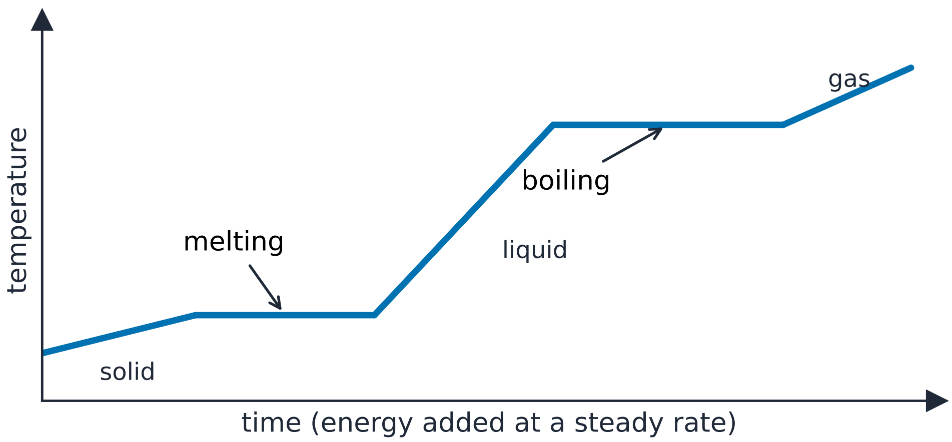
Build the skills to answer exam questions on **thermal properties 热学性质** — the kelvin scale, **thermal expansion 热膨胀**, **specific heat capacity 比热容**, and melting/boiling/evaporation.

**You must be able to:**

- convert between °C and kelvin ($T = \theta + 273$)
- use $\Delta E = mc\,\Delta\theta$
- describe state changes and explain cooling by evaporation

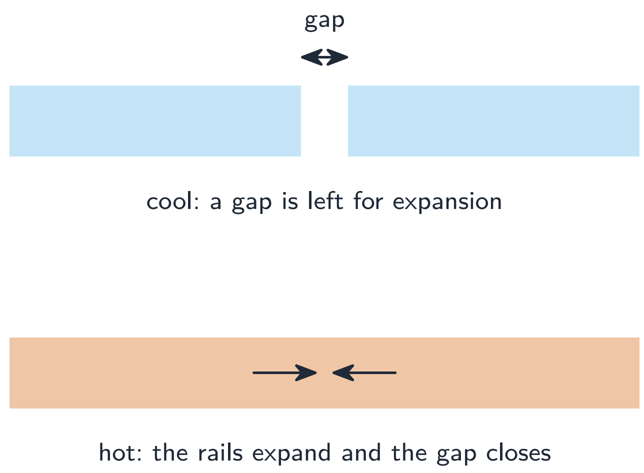
## 1 Worked examples

### ■ Specific heat capacity




plateau: latent heat changes state at constant temperature

*During melting and boiling the temperature stays flat while energy is still added*




*Solids expand on heating — a gap is left so the track does not buckle*

**Heat 2.0 kg water by 50 °C ($c = 4200$):** $\Delta E = mc\Delta\theta = 2.0 \times 4200 \times 50 = 420\,000$ J.

## ■ The state changes, and measuring $c$

**Condensation** 凝结 is a gas becoming a liquid: the particles slow down, come close together and the attractions hold them. **Solidification** 凝固 is a liquid becoming a solid: the particles lose more energy and settle into fixed positions in a lattice. During melting and boiling the temperature does not change, because the energy goes into breaking the forces between particles rather than into speeding them up.

**Thermal expansion.** Heated particles vibrate or move more and take up more space. Gases expand most, then liquids, then solids, because the forces between particles are weakest in a gas and strongest in a solid. Everyday consequences: gaps between railway rails, rollers under a bridge, a tight metal lid freed by hot water, and a liquid-in-glass thermometer working at all.

**Measuring specific heat capacity.** Use a metal block with two holes, one for an electric heater and one for a thermometer. Measure the mass $m$; switch the heater on for a measured time $t$, recording $I$ and $V$, so the energy supplied is $E = IVt$; record the temperature rise $\Delta\theta$ and use $c = \dfrac{E}{m\,\Delta\theta}$. For a liquid, heat a known mass in a container and stir it. Insulate the block or container, because energy escaping to the air makes the value of $c$ come out too large.

**Worked example.** A 2.0 kg block is heated by a 50 W heater for 5.0 minutes and rises from 7.0 °C to 22.0 °C. Energy supplied $= Pt = 50 \times 300 = 15\,000$ J; $\Delta\theta = 15.0$ °C; $c = \dfrac{15\,000}{2.0 \times 15.0} = 500$ J/(kg °C).

## 2 Practice

**2.1** Convert 25 °C to kelvin. [1]

**2.2** State why a liquid cools as it evaporates. [1]

**2.3** Describe condensation and solidification in terms of particles. [2]

**2.4** Explain why a gas expands more than a solid for the same temperature rise. [2]

**2.5** State two everyday consequences of thermal expansion. [2]

## 3 Exam-style questions

**3.1** While a pure solid is melting, its temperature: [1]

- **A** rises steadily
- **B** stays constant
- **C** falls
- **D** rises then falls

**3.2** A 0.50 kg metal block is given 9000 J of energy and its temperature rises by 40 °C.

(a) Find the specific heat capacity of the metal. [3]

(b) State one reason the actual value might be higher than calculated. [1]

**3.3** Explain, using the particle model, why evaporation cools the remaining liquid. [2]

**3.4** A student measures the specific heat capacity of sand. She puts 0.80 kg of dry sand in an insulated pot with an electric heater and a thermometer.

(a) Describe the measurements she must take. [3]

(b) The 50 W heater runs for 4.0 minutes and the temperature rises from 7.0 °C to 22.0 °C. Calculate the energy supplied. [2]

(c) Calculate the specific heat capacity of the sand. [3]

(d) Her value is larger than the true value. Explain why, and state one improvement. [2]

(e) The heater is left on and the temperature of the sand stops rising. Explain why. [1]

## Solutions

**2.1** $25 + 273 = 298$ K.

**2.2** the fastest particles escape, lowering the average energy of those left.

**2.3** Condensation: the gas particles slow down and come close enough for the attractions between them to hold them as a liquid. Solidification: the liquid particles lose more energy and settle into fixed positions in a regular pattern.

**2.4** The forces between gas particles are very weak, so they are free to spread much further apart; in a solid strong forces hold the particles in a lattice, so they only vibrate a little more.

**2.5** Any two of: gaps left between railway rails; a bridge resting on rollers; a tight metal lid loosened in hot water; the liquid rising in a thermometer.

**3.1** **B**. The temperature stays constant during a change of state.

**3.2** (a) $c = \dfrac{\Delta E}{m\,\Delta\theta} = \dfrac{9000}{0.50 \times 40}$; $= 450$ J/(kg °C).
(b) some energy is lost to the surroundings, so more than 9000 J was really needed.

**3.3** the most energetic particles leave the surface; so the average kinetic energy — and the temperature — of the remaining particles falls.

**3.4** (a) The mass of the sand; the temperature before and after heating, giving the rise; the time the heater is on together with its power, or the current and voltage, giving the energy.
(b) $E = Pt = 50 \times (4.0 \times 60) = 12\,000$ J.
(c) $\Delta\theta = 22.0 - 7.0 = 15.0$ °C; $c = \dfrac{E}{m\,\Delta\theta} = \dfrac{12\,000}{0.80 \times 15.0} = 1000$ J/(kg °C).
(d) Some supplied energy escapes to the surroundings instead of heating the sand, so the calculated $c$ is too large; add more insulation, or a lid.
(e) The sand is losing energy to the surroundings as fast as the heater supplies it, so there is no net gain.

**13** A circular, flat-bottomed dish contains 100 $cm^3$ of water.

Students are asked how to increase the rate at which the water evaporates.

Their suggestions are listed.

student 1 Pour the water into a flat-bottomed dish of larger diameter.

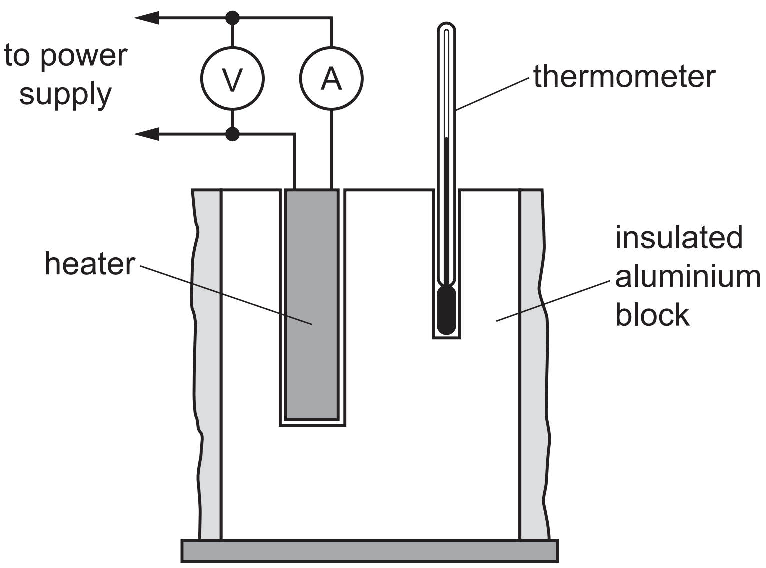
student 2 Cool the dish and water.

student 3 Create a current of air over the dish with a fan.

Which suggestions will increase the rate of evaporation?

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**15** The diagram shows the equipment used in an experiment on the heating of aluminium.




The table gives the results for the experiment.

| | |
|---|---|
| mass of block | 0.80 kg |
| voltmeter reading | 12 V |
| ammeter reading | 5.0 A |
| time | 300 s |

The specific heat capacity of aluminium is 900 J / (kg °C).

What is the maximum possible temperature rise in the block?

**A** 9 °C **B** 20 °C **C** 25 °C **D** 225 °C

**4** **(a)** Define specific heat capacity.

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

**(b)** A volume of $0.0024\,m^3$ of oil is heated in a pan for 7.0 min. The temperature of the oil increases from 20 °C to 180 °C.

The density of the oil is $910\,kg/m^3$. The specific heat capacity of the oil is 2000 J/(kg °C).

**(i)** Calculate the mass of oil in the pan.

mass = ......................................................... [2]

**(ii)** Calculate the energy required to increase the temperature of the oil.

energy = ......................................................... [2]

**(iii)** Calculate the power required to supply the energy calculated in **(b)(ii)**.

power = ......................................................... [2]

[Total: 8]

**4** Fig. 4.1 shows a metal pan on an electric hotplate. The pan contains 200 $cm^3$ of water.

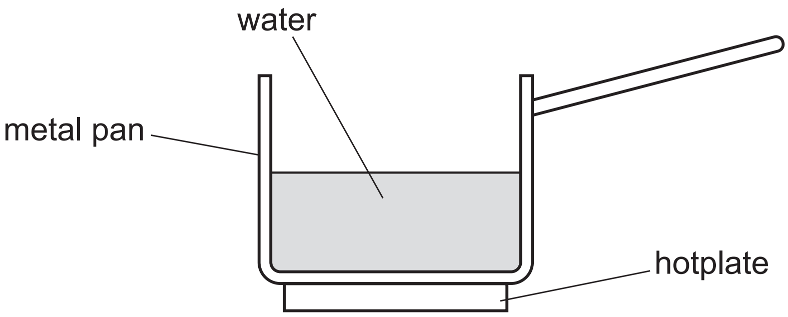


**Fig. 4.1**

The pan is heated. The temperature of the water in the pan increases.

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**(b)** **(i)** The water boils and leaves the liquid as a gas.

Explain, in terms of forces and distances between particles, why the gas occupies a much greater volume than it does as a liquid.

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

**(ii)** State **two** ways in which boiling differs from evaporation.

1 ......................................................................................................................................

2 ......................................................................................................................................

[2]

**(c)** The water is replaced with 200 $cm^3$ of milk.

The initial temperature of the milk is 20.0 °C. The boiling point of milk is 95.0 °C.

The milk starts to boil when 60 700 J of thermal energy has been transferred to it. The density of milk is 1.03 $g/cm^3$.

Calculate the value of the specific heat capacity of milk. Give your answer to 3 significant figures.

specific heat capacity = ........................................................ [4]

[Total: 11]

**3** Fig. 3.1 and Fig. 3.2 show how a puddle of water changes on a warm windy day.

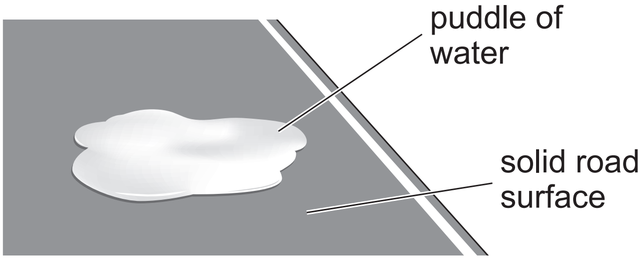


**Fig. 3.1**

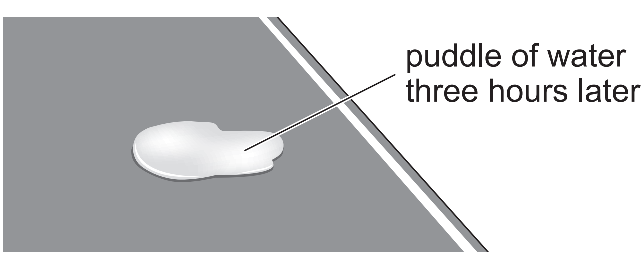


**Fig. 3.2**

**(a)** Describe the process by which the volume of water in the puddle decreases.

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

**(b)** State and explain **one** change in the weather that would cause the volume of water in the puddle to decrease more slowly.

statement ..........................................................................................................................

explanation .......................................................................................................................

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

**(c)** Explain, in terms of molecules, how sweating helps to cool your body on a hot day.

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

[Total: 7]

# 2.3 Transfer of thermal energy

Name: ______________ Class: __________ Date: ____________ **Total: 30 marks**

**KEY WORDS** thermal conductor 热导体 • radiation 热辐射 • convection 对流 • transfer of thermal energy 热能传递 • infrared 红外线 • convection 对流 • radiation 热辐射 • infrared 红外线 • transfer of thermal energy 热能传递 • dull 暗淡

## Objective

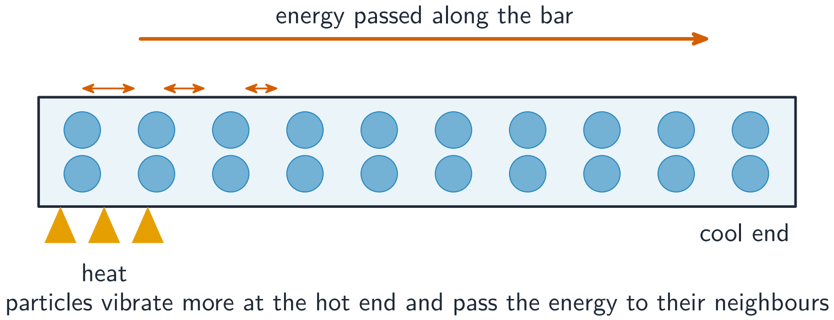
Build the skills to answer exam questions on the **transfer of thermal energy** 热能传递 — **conduction** 热传导, **convection** 对流 and **radiation** 热辐射.

**You must be able to:**

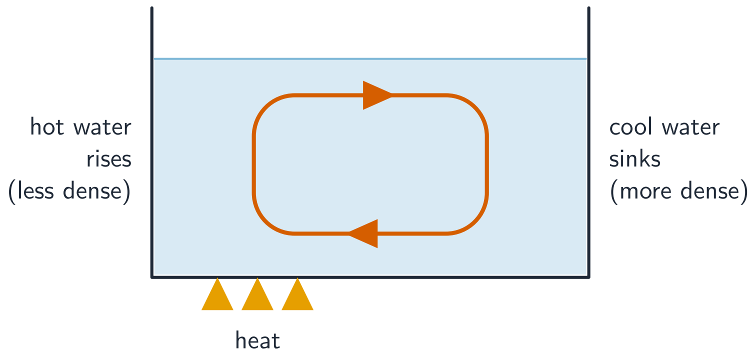
- explain conduction (and why metals are good conductors)
- explain convection currents in fluids
- describe thermal radiation and good/poor emitters

## 1 Worked examples

### ■ Three transfer methods




*Conduction: vibrating particles (and free electrons in metals) pass energy along*




*Convection: heated fluid expands, becomes less dense and rises; cooler fluid sinks*

- **conduction:** energy passed by vibrating particles; metals conduct best (free electrons).
- **radiation:** infrared waves, no material needed; dull-black surfaces emit/absorb best.

## Doing the experiments, and the Earth's balance

**Comparing conductors.** Fix a drawing pin with a little wax to one end of rods of copper, iron, glass and wood and heat the other ends equally. The pin drops first from the copper, then the iron, and last or never from the glass and wood. Metals win because free electrons carry energy as well as the vibrating **lattice** 晶格; gases and most liquids conduct badly because their particles are far apart and exchange energy only when they collide.

**Showing convection.** Drop a crystal of purple potassium permanganate into a beaker of water and heat gently below it: a coloured stream rises above the heat, spreads across the top and sinks at the sides. Explain it by density: heated fluid expands, so the same mass fills a larger volume, its density falls and it rises; cooler, denser fluid sinks to replace it.

**Comparing emitters and absorbers.** Fill a dull black can and a shiny silver can with hot water at the same temperature: the black one cools faster, so it is the better emitter. Fill both with cold water and place them equally far from a heater: the black one warms faster, so it is the better absorber. The rate of emission is greater when the surface is **hotter** and when it is **larger**.

**The Earth's temperature.** The Earth absorbs radiation from the Sun and emits infrared back into space. Its average temperature stays constant only while the two rates are equal: absorb faster and it warms, emit faster and it cools. Greenhouse gases in the atmosphere absorb some of the emitted infrared and send part back down, so more of them means a warmer Earth.

**Everyday examples.** A kitchen pan has a metal base (conduction into the food) and a plastic handle (an insulator). A radiator warms a room by convection. You feel a fire's radiation at once, because radiation needs no material. A vacuum flask blocks all three: the vacuum stops conduction and convection, the shiny surfaces stop radiation.

## 2 Practice

**2.1** State why metals are good conductors of thermal energy. [1]

**2.2** State which surface is the best emitter of infrared radiation. [1]

**2.3** Describe an experiment to show which of two solids is the better thermal conductor. [3]

**2.4** Explain, in terms of density, why heated water rises in a beaker. [2]

**2.5** State two factors that increase the rate at which a surface emits radiation. [2]

## 3 Exam-style questions

**3.1** Convection cannot take place in a solid because: [1]

- **A** solids have no particles
- **B** the particles cannot move from place to place
- **C** solids are too cold
- **D** solids do not conduct

**3.2** A beaker of water is heated at the bottom.

(a) Explain how a convection current forms. [3]

(b) State why heating at the top would not set up a convection current. [1]

**3.3** Two metal cans are filled with hot water; one is dull black and one is shiny silver. State and explain which cools faster. [2]

**3.4** A vacuum flask keeps a hot drink hot. It has double glass walls with a vacuum between them, and both glass surfaces are silvered.

(a) Explain how the vacuum reduces the energy lost by conduction and by convection. [2]

(b) Explain how the silvered surfaces reduce the energy lost by radiation. [2]

(c) The stopper is plastic. Explain why plastic is used rather than metal. [2]

(d) A student leaves the same drink in an open metal mug. State the main way energy leaves the surface of the drink, and one way to reduce it. [2]

**3.5** The Earth absorbs radiation from the Sun and emits infrared radiation into space.

(a) State the condition for the average temperature of the Earth to stay constant. [1]

(b) Explain how an increase in greenhouse gases raises the average temperature. [2]

(c) A dark tarmac road and the air above it both become hotter on a sunny day. Explain how the road gets hot, and how the air above it then gets hot. [3]

## Solutions

**2.1** they contain free (delocalised) electrons that carry energy quickly.

**2.2** a dull, black surface.

**2.3** Fix a drawing pin to one end of each rod with wax; heat the other ends equally; the pin on the better conductor falls first, because energy reaches its end sooner.

**2.4** Heated water expands, so the same mass occupies a larger volume and its density falls; the less dense water floats up through the denser water around it.

**2.5** A higher surface temperature and a larger surface area. (A duller, blacker surface also emits faster.)

**3.1 B**. In a solid the particles vibrate in fixed positions and cannot move from place to place.

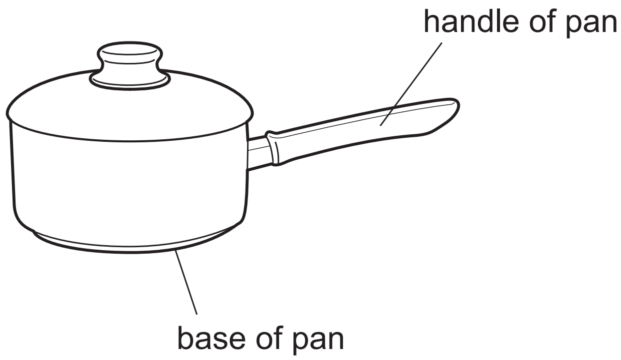
**3.2** (a) the water at the bottom is heated, expands and becomes less dense; it rises, and cooler, denser water sinks to replace it; this circulation is a convection current.
(b) hot (less dense) water would already be at the top, so there is nothing to make it rise — no current forms.

**3.3** the dull black can cools faster; because a dull, black surface is a better emitter of infrared radiation.

**3.4** (a) Conduction and convection both need particles; the vacuum has almost none, so neither can carry energy across the gap.
(b) Shiny silver surfaces are poor emitters, so little infrared leaves the inner wall, and they are good reflectors, so radiation crossing the gap is reflected back.
(c) Plastic is a poor conductor, so little energy is conducted out through the stopper; a metal stopper would conduct energy away quickly.
(d) Evaporation from the surface, or convection of the warm air above it; put a lid on the mug.

**3.5** (a) It absorbs energy at the same rate as it emits it.
(b) Greenhouse gases absorb some of the infrared emitted by the Earth and re-emit part of it back towards the surface, so less energy escapes and the Earth warms until the rates balance again.
(c) The road absorbs radiation from the Sun, and a dull black surface is a good absorber, so its temperature rises; the air touching the road is warmed by conduction; that warmed air expands, becomes less dense and rises, carrying energy upwards by convection while cooler air moves in.

**10** The diagram shows a pan used for cooking food.




Which row is correct for the materials used to make the base of the pan and the handle of the pan?

| | base of pan | handle of pan |
|---|---|---|
| **A** | good thermal conductor | good thermal conductor |
| **B** | good thermal conductor | poor thermal conductor |
| **C** | poor thermal conductor | good thermal conductor |
| **D** | poor thermal conductor | poor thermal conductor |

**11** Solar heating panels consist of pipes carrying water that absorb radiation from the Sun.

Which texture and colour is the surface of the pipes so that the temperature of the water rises at the quickest rate?

**A** dull black

**B** dull white

**C** shiny black

**D** shiny white

IGCSE Physics: **m23 22**

**17** A bar of metal, which is a good thermal conductor, is heated at one end.

What is the main method of transfer of thermal energy along the bar?

**A** lattice vibration

**B** movement of atoms of the metal along the bar

**C** transfer by electrons

**D** vibration of atoms of the metal bar

**4** Fig. 4.1 shows a metal pan on an electric hotplate. The pan contains 200 $cm^3$ of water.

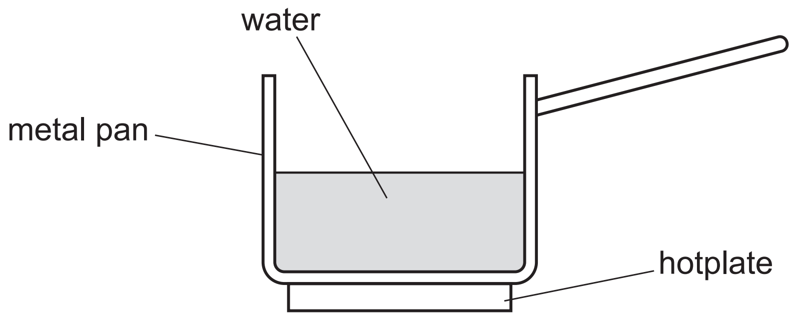



**Fig. 4.1**

The pan is heated. The temperature of the water in the pan increases.

**(a)** Thermal energy is transferred through the metal pan by conduction.

State and explain the **two** ways that thermal energy is conducted in a metal.

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**(b)** **(i)** The water boils and leaves the liquid as a gas.

Explain, in terms of forces and distances between particles, why the gas occupies a much greater volume than it does as a liquid.

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**(ii)** State **two** ways in which boiling differs from evaporation.

1 ..........................................................................................................................................

2 ..........................................................................................................................................

[2]

**(c)** The water is replaced with 200 $cm^3$ of milk.

The initial temperature of the milk is 20.0 °C. The boiling point of milk is 95.0 °C.

The milk starts to boil when 60 700 J of thermal energy has been transferred to it. The density of milk is 1.03 $g/cm^3$.

Calculate the value of the specific heat capacity of milk. Give your answer to 3 significant figures.

specific heat capacity = ......................................................... [4]

[Total: 11]

**4** **(a)** A sample of sand has a volume of $0.050\,m^3$. The density of the sand is $1900\,kg/m^3$. The specific heat capacity of the sand is $1500\,J/(kg\,°C)$.

**(i)** Calculate the mass of the sample of sand.

mass = .................................................... [2]

**(ii)** Calculate the thermal capacity of the sample of sand.

thermal capacity = .................................................... [2]

**(iii)** The initial temperature of the sample of sand is 7.0 °C. The sample of sand is heated using an electrical heater. The power of the heating element is 50 W.

Calculate the time taken to increase the temperature of the sand to 19.0 °C.

time = .................................................... [3]

**(b)** In some countries, the soil is too cold for plants to grow well. In these countries, plants are grown in plastic pots and kept inside. The pots, containing soil, are placed on sand. The sand is heated using an electrical heater, as shown in Fig. 4.1.

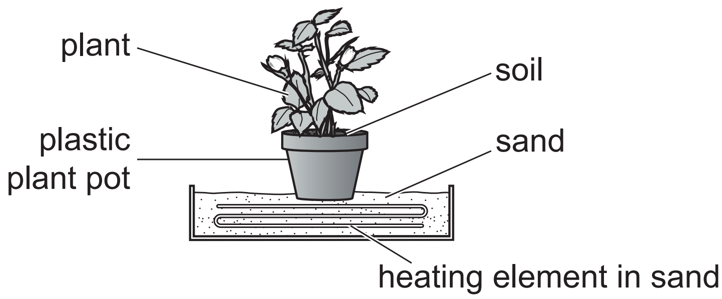


**Fig. 4.1**

**(i)** Describe, in terms of molecules, how thermal energy is transferred from the heated sand through the base of the plastic pot.

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[2]

**(ii)** The heating element in Fig. 4.1 remains switched on. The temperature of the sand remains constant at a value above room temperature.

Explain why the temperature of the sand remains constant.

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[Total: 11]