2. Thermal physics

2.3 Transfer of thermal energy

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 Fig. 6.1 shows a wood burner in a cabin. The wood burner keeps the inside of the cabin warm when it is cold outside.

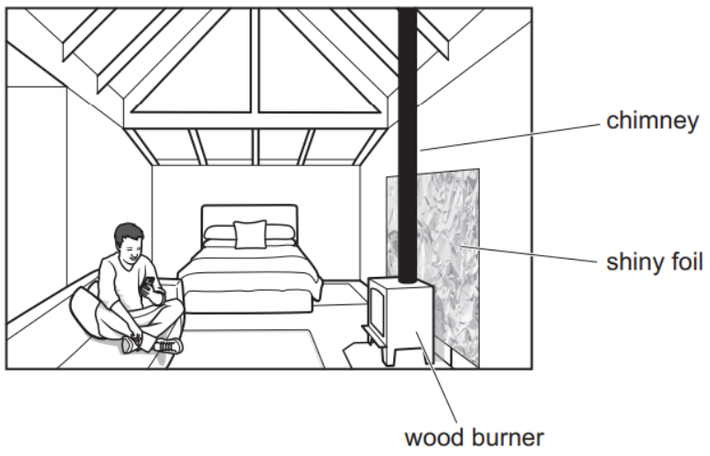

Fig. 6.1

(a) Explain how thermal energy from the wood burner warms the cabin by convection.
Use your ideas about the density of air. You may draw on Fig. 6.1 as part of your answer.

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.....

..... [3]

(b) **(i)** The outer surface of the chimney is dull and black.
Explain how the dull black surface helps to warm the cabin.

.....

.....

..... [2]

(ii) There is shiny foil on the wall.
Explain how the shiny foil helps to warm the cabin.

.....

.....

.....

..... [2]

[Total: 7]

2 A student wants to compare the conduction of thermal energy through rods made of iron, copper, glass and aluminium. Each rod is coated with wax.

Fig. 6.1 shows the equipment that the student uses.

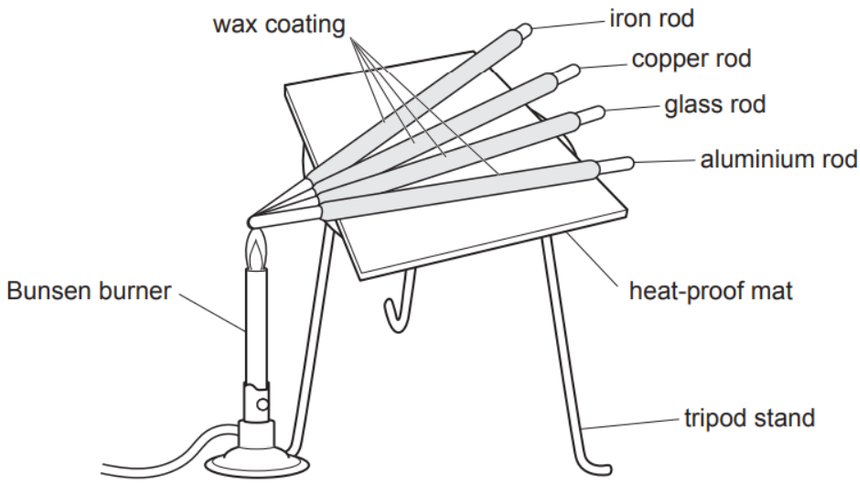

Fig. 6.1

(a) Describe how the student can compare the conduction of thermal energy through the rods in Fig. 6.1.

.....

.....

..... [2]

(b) The Bunsen burner emits infrared waves.

The infrared waves have a wavelength of 2.0×10^{-6} m.
The velocity of the infrared waves is 3.0×10^{8} m/s.

(i) Calculate the frequency of the infrared waves.

frequency = ... Hz [3]

(ii) State the name of a region of the electromagnetic spectrum which has a wavelength longer than the wavelength of infrared. Give **one** use of the radiation in this region.

region .....

use .....
[2]

[Total: 7]

3 **(c)** Fig. 3.3 shows a fire heating water in a metal pan.

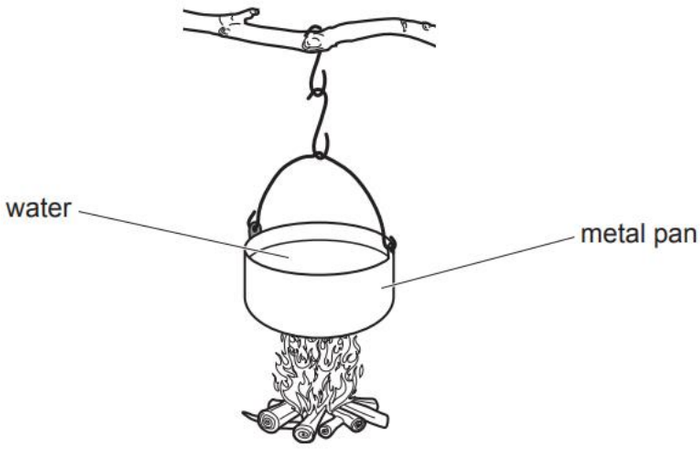

Fig. 3.3

(i) State the name of the process of thermal energy transfer through the metal of the pan.

..... [1]

(ii) Describe how thermal energy is transferred through the water by convection.

.....

.....

..... [3]

(iii) State the temperature at which the water boils at standard atmospheric pressure.

temperature = ... °C [1]

[Total: 10]

4 **(a)** Fig. 6.1 shows a cold drink in a thermal jug. The jug reduces thermal energy transfer from the surroundings to the drink.

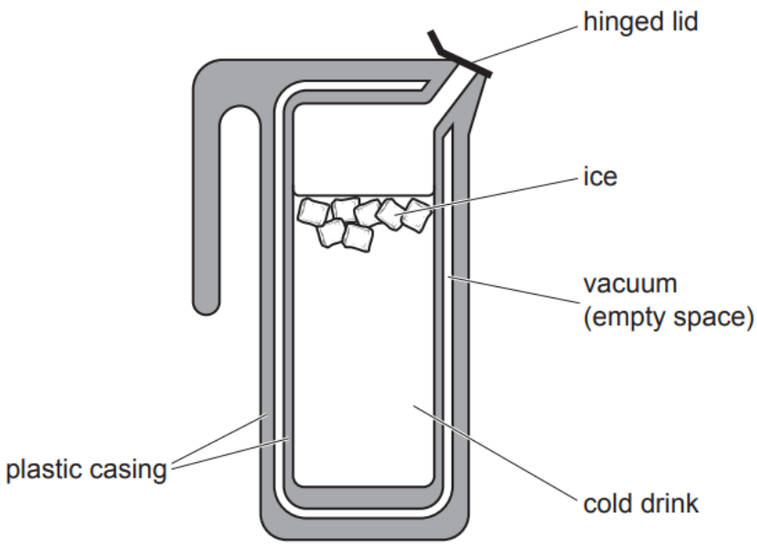

Fig. 6.1

State the names of the **two** processes of thermal energy transfer that are prevented by the vacuum.

Explain how the vacuum prevents these **two** processes of thermal energy transfer.

processes ..... and .....

explanation .....

.....

[2]

(b) Fig. 6.2 represents a demonstration that shows how water moves when heated.
The colour from the crystal shows the flow of the water.

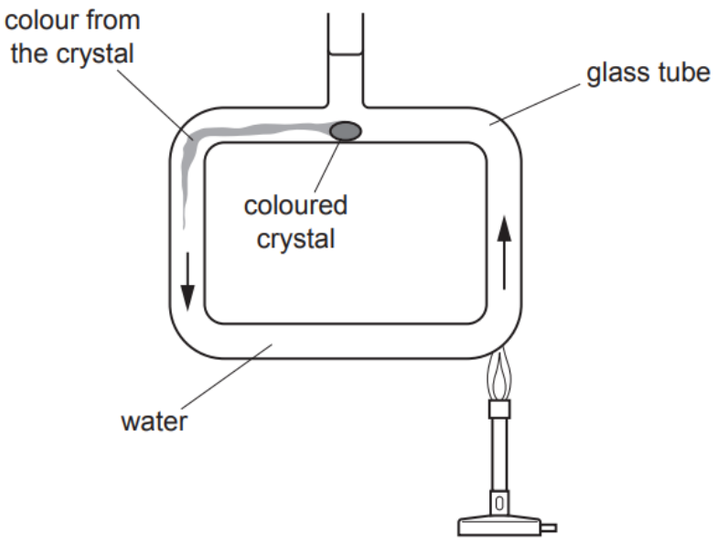

Fig. 6.2

The arrows in Fig. 6.2 show the direction of flow of water in the glass tube when the water is heated.

Explain why the water moves in this way. Use your ideas about density.

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..... [4]

[Total: 6]

5 **(b)** A student designs a container to keep a hot liquid at a high temperature.
The container is shown in Fig. 4.2.

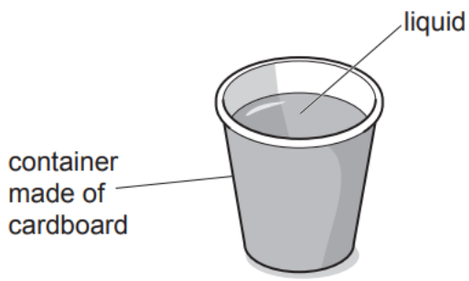

Fig. 4.2

He finds that the liquid cools too quickly.

Suggest **two** improvements to the design of the container which reduce the transfer of thermal energy from the hot liquid to its surroundings.
For each suggestion, state the thermal transfer process that it reduces.

suggestion 1 .....

.....

thermal transfer process .....

suggestion 2 .....

.....

thermal transfer process .....
[4]

[Total: 8]

6 **(b)** Some of the hot liquid is poured out of the flask into a shallow dish.

Explain how evaporation causes the liquid to cool.

.....

.....

..... [3]

7 Fig. 6.1 shows equipment used to demonstrate convection in air. A burning candle is placed beneath glass tube A.

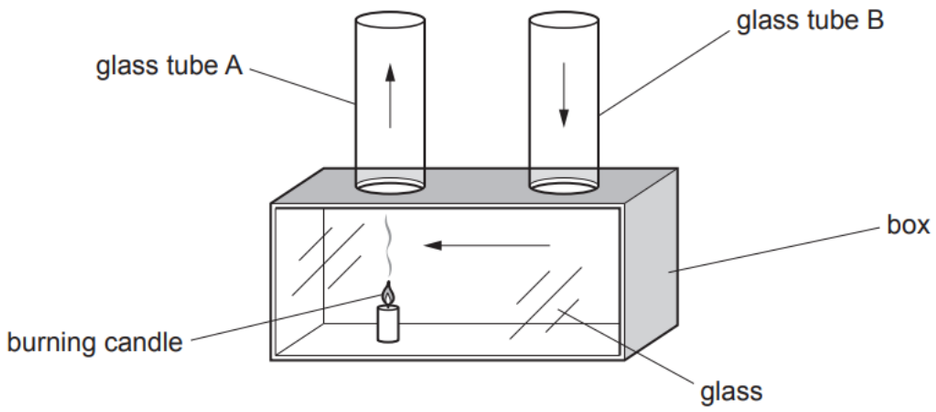

Fig. 6.1

(a) The arrows in Fig. 6.1 show the directions in which air moves.

Explain why the air moves as shown in Fig. 6.1.

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..... [3]

(b) A student has four rods of identical size. The rods are made of copper, brass, iron and glass.

Describe an experiment to compare thermal conduction along the rods.

You may draw a labelled diagram to help with your answer.

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..... [3]

[Total: 6]

8 Fig. 6.1 shows a hot liquid in a vacuum flask. The vacuum flask keeps the temperature of the liquid in the flask constant for a long time.

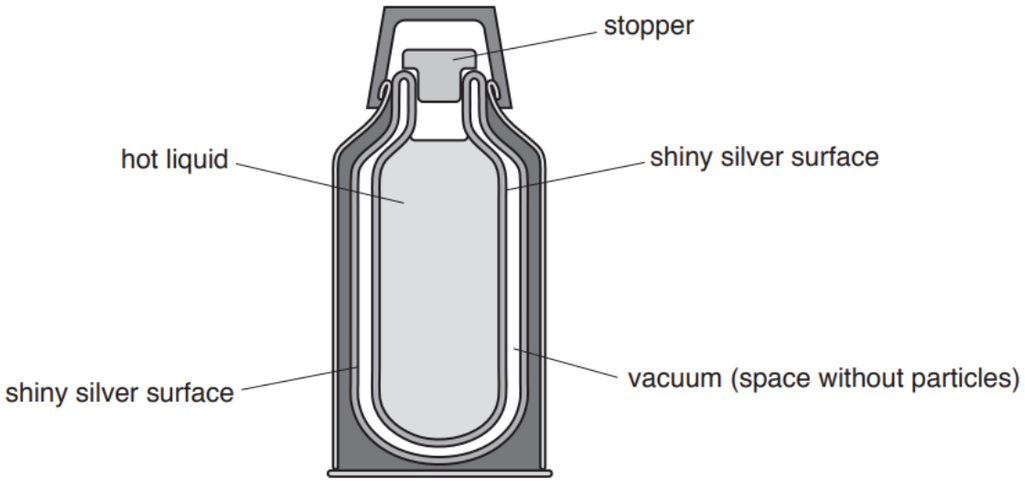

Fig. 6.1

(a) Describe how each feature helps to keep the liquid hot for longer.

(i) shiny silver surface

.....

..... [2]

(ii) the vacuum between the silvered surfaces

.....

.....

..... [3]

(b) **(i)** Suggest a material for the stopper that will help to keep the liquid hot for longer.

material ..... [1]

(ii) Give a reason for your answer.

reason .....

..... [1]

[Total: 7]

9 **(b)** A student heats some water in a metal can, as shown in Fig. 6.2.

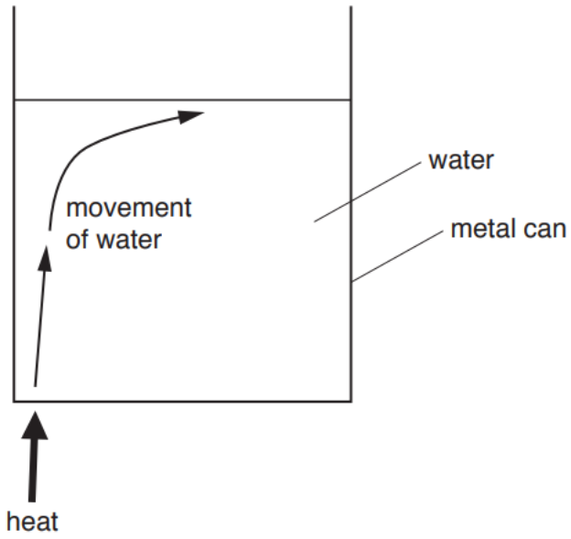

Fig. 6.2

(i) Complete the sentence. Choose a word from the box.

conduction	convection	radiation

Thermal (heat) energy moves through the metal can by ..... [1]

(ii) Describe how thermal energy is transferred throughout the water. Include your ideas about density changes.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 6]

10 **(a)** Some materials are poor conductors of thermal energy (heat energy).

State the term that describes materials that are poor conductors of thermal energy.

.....[1]

(b) Some materials are good conductors of thermal energy.

Draw a ring around each material that is a good conductor of thermal energy.

air aluminium copper glass plastic water [1]

(c) A student has two rods made of different materials. The rods are the same size.

Describe an experiment to identify which material is the better conductor of thermal energy.

You may draw a diagram in the space below.

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.....[3]

[Total: 5]

11 Fig. 5.1 shows a cross-section of a flask. The flask is used to keep a liquid hot. The flask has two glass walls with a vacuum between them. The surfaces of the glass walls are shiny.

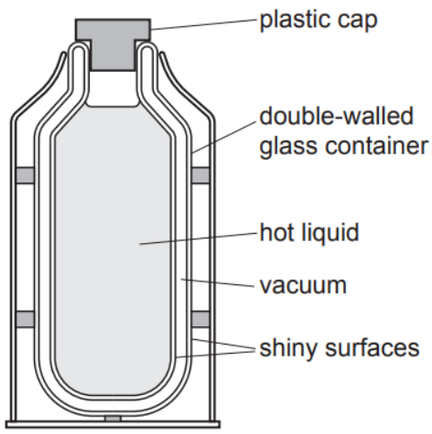

Fig. 5.1

(a) (i) Explain how the shiny surfaces reduce the transfer of thermal energy from the hot liquid.

.....

..... [2]

(ii) Explain how the vacuum reduces the transfer of thermal energy from the hot liquid.

.....

..... [2]

Paper 4

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

12 On a sunny day, the temperatures of a black tarmac road and the air above the road increase.

(a) Explain why the surface temperature of the tarmac increases.

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..... [2]

(b) State the method of thermal energy transfer from the tarmac to the air **immediately** above the road.

..... [1]

(c) State the main method of thermal energy transfer from the air immediately above the road to the rest of the air.

..... [1]

(d) Explain why the surface temperature of the tarmac is higher than the surrounding air temperature.

.....

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..... [2]

[Total: 6]

13 Fig. 3.1 shows a small block of ice floating in a beaker of warm water.

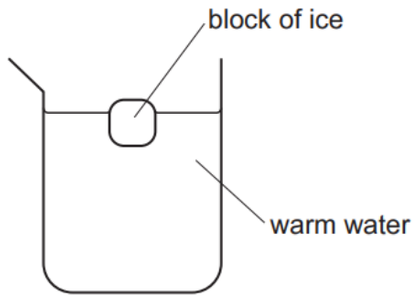

Fig. 3.1

(a) State **one** way in which the motion of the particles in ice differs from the motion of the particles in water.

.....

..... [1]

(b) Energy is transferred from the water to the block of ice.

(i) State the name of the thermal process that transfers energy from the water to the ice.

..... [1]

(ii) Initially, there is 0.34 kg of water in the beaker. The specific heat capacity of water is 4200 J/(kg °C). **(extended only)**

Calculate the energy transferred from this water as its temperature decreases from 28 °C to 10 °C.

energy transferred = ... [2]

(iii) The temperature of the water near the ice decreases first.

Explain how convection causes the temperature of all the water in the beaker to decrease.

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..... [3]

(iv) State what happens to the internal energy of the water as the temperature of the water decreases. **(extended only)**

Describe the change in terms of the energy of the particles.

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..... [2]

[Total: 9]

14 A copper cooking pan contains water. Fig. 2.1 shows the pan on a hotplate of a cooker.

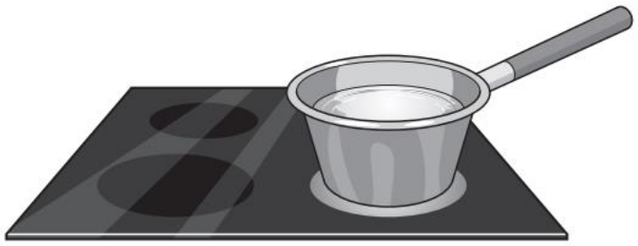

Fig. 2.1

Copper is a metal.

(a) Thermal energy is conducted through all solids by lattice vibrations. **(extended only)**

Describe **one** other way in which thermal energy is conducted through the copper.

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..... [3]

(b) The outside surface of the cooking pan is kept clean by regular polishing.

Explain **one** other advantage of keeping the surface of the pan shiny.

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..... [2]

(c) The thermal energy passes into the water through the base of the pan.

Identify the main method by which thermal energy is transferred throughout the water.

..... [1]

[Total: 6]

15 Fig. 5.1 shows a heater in a bathroom.

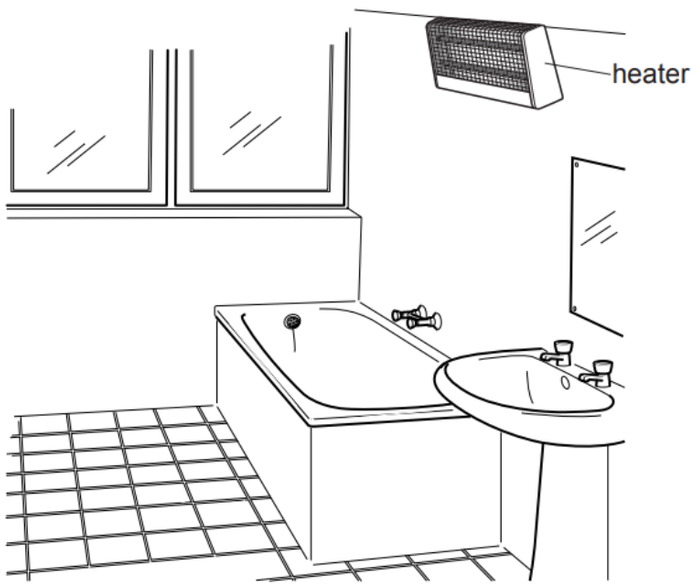

Fig. 5.1

The heater is at a very high temperature and it glows red. The manufacturer states:

> "The heater emits light and radiation and it transfers thermal energy by radiation."

(a) State the part of the electromagnetic spectrum that transfers thermal energy.

.....[1]

(b) State:

(i) **one** way in which visible light and the radiation identified in **(a)** are similar

.....

.....[1]

(ii) **one** way in which visible light differs from the radiation identified in **(a)**.

.....

.....[1]

(c) Some surfaces are better at emitting radiation than others.

(i) Describe an experiment to show whether a black surface or a white surface is the better emitter of radiation. You may draw a diagram. **(extended only)**

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..... [3]

(ii) To ensure that the conclusion reached in the experiment in **(c)(i)** is correct, several details of the experiment must be identical when testing the two different surfaces. **(extended only)**

State **two** quantities in the experiment that you described that must be identical during the test.

1. .....

.....

2. .....

.....

[2]

16 Fig. 5.1 shows an aluminium block after leaving a furnace in a factory.

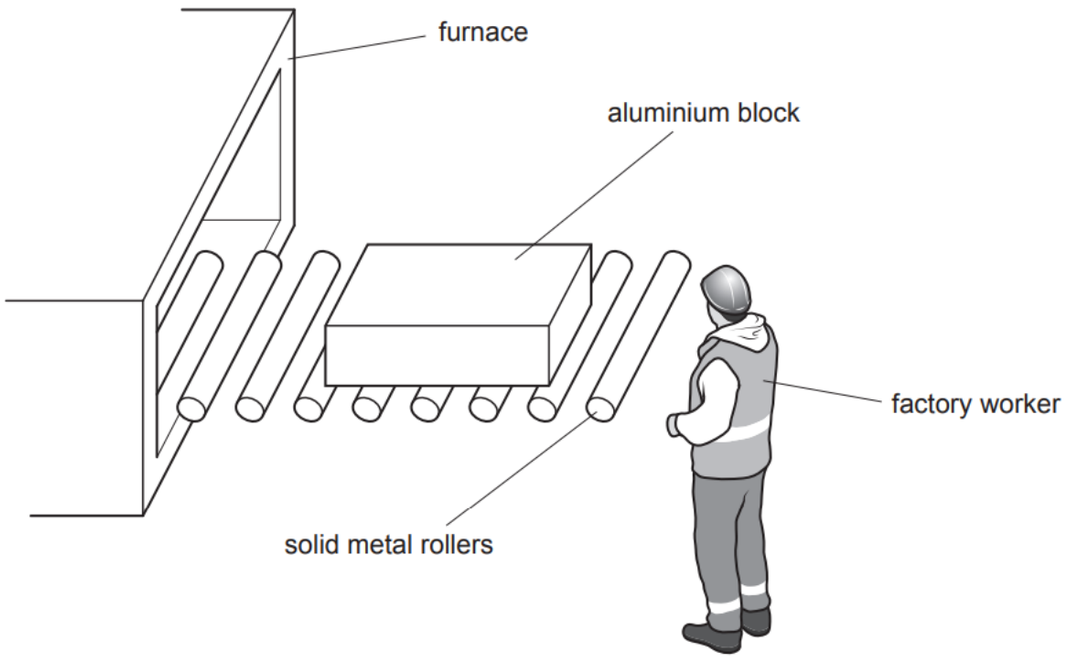

Fig. 5.1

(b) Fig. 5.1 shows a factory worker standing 3 m from the block.

State and explain the main process by which thermal energy is transferred to the worker.

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..... [3]

(c) State and explain the main process by which thermal energy is transferred from the outer surface of the solid metal rollers to their interior.

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..... [3]

17 During a picnic on a warm, dry day, a metal can of lemonade is wrapped in a damp cloth.

Evaporation cools the water in the cloth.

(b) As the water in the cloth cools, so does the lemonade. **(extended only)**

Explain how electrons transfer thermal energy through the metal of the can.

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..... [3]

18 **(a)** A machine delivers a hot drink in a plastic cup, which is uncomfortably hot to hold.

Fig. 5.1 shows the cup with the hot drink.

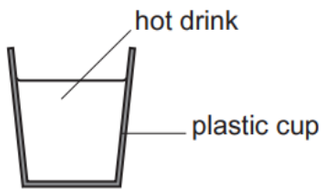

Fig. 5.1

Fig. 5.2a shows the cup with the hot drink and a holder for the sides of the cup.

Fig. 5.2b shows a cross-section through the holder. The holder is made from two strong paper cylinders separated by a wavy piece of strong paper to make air gaps.

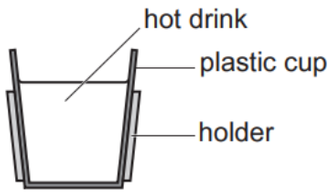

Fig. 5.2a

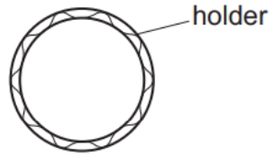

Fig. 5.2b

Explain how using the holder makes it more comfortable to hold the cup.

.....

.....

..... [3]

(b) A student carries out experiments on the cooling of the hot drink described in **(a)**, with and without the holder in place. He finds that the holder only reduces the rate of cooling slightly.

Suggest and explain another action that reduces the rate of cooling more effectively.

suggestion .....

explanation .....

.....

..... [3]

(c) State the method of thermal energy transfer from a star through the vacuum of space.

..... [1]

[Total: 7]

19 A metal container is used to cook food. The metal container has thick walls. Hot cooking oil at a temperature of 120 °C is poured into the container.

(a) The outside surface of the container gets hot. Some thermal energy passes through the metal because vibrating atoms in the metal collide with neighbouring atoms and transfer energy to them. **(extended only)**

Explain how the rest of the thermal energy is conducted through the metal container to the outside surface by another process.

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..... [3]

(b) The outside surface of the container is brightly polished and shiny.

Explain how this reduces the power that needs to be supplied to keep the oil at the correct temperature.

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.....

.....

..... [3]

(c) The metal container is spherical. The spherical container has a smaller surface area than a long, thin container of the same volume. **(extended only)**

Explain the advantage of using a spherical container.

.....

.....

..... [1]

[Total: 7]