Chapter 11. Thermal energy transfers

2.3.1 Conduction

Core

1 Describe experiments to demonstrate the properties of good thermal conductors and bad thermal conductors (thermal insulators)

Supplement

2 Describe thermal conduction in all solids in terms of atomic or molecular lattice vibrations and also in terms of the movement of free (delocalised) electrons in metallic conductors

3 Describe, in terms of particles, why thermal conduction is bad in gases and most liquids

4 Know that there are many solids that conduct thermal energy better than thermal insulators but do so less well than good thermal conductors

2.3.2 Convection

Core

1 Know that convection is an important method of thermal energy transfer in liquids and gases

2 Explain convection in liquids and gases in terms of density changes and describe experiments to illustrate convection

Supplement

2.3.3 Radiation

Core

1 Know that thermal radiation is infrared radiation and that all objects emit this radiation

2 Know that thermal energy transfer by thermal radiation does not require a medium

3 Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of infrared radiation

Supplement

4 Know that for an object to be at a constant temperature it needs to transfer energy away from the object at the same rate that it receives energy

5 Know what happens to an object if the rate at which it receives energy is less or more than the rate at which it transfers energy away from the object

6 Know how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted from the Earth's surface

continued

Chapter 11. Thermal energy transfers

2.3.3 Radiation continued

Core

Supplement

7 Describe experiments to distinguish between good and bad emitters of infrared radiation

8 Describe experiments to distinguish between good and bad absorbers of infrared radiation

9 Describe how the rate of emission of radiation depends on the surface temperature and surface area of an object

2.3.4 Consequences of thermal energy transfer

Core

1 Explain some of the basic everyday applications and consequences of conduction, convection and radiation, including:

(a) heating objects such as kitchen pans

(b) heating a room by convection

Supplement

2 Explain some of the complex applications and consequences of conduction, convection and radiation where more than one type of thermal energy transfer is significant, including:

(a) a fire burning wood or coal

(b) a radiator in a car

1 **(a)** Fig. 5.1 shows two identical metal plates. The front surface of one is dull black and the front surface of the other is shiny silver.
The plates are fitted with heaters that keep the surfaces of the plates at the same temperature.

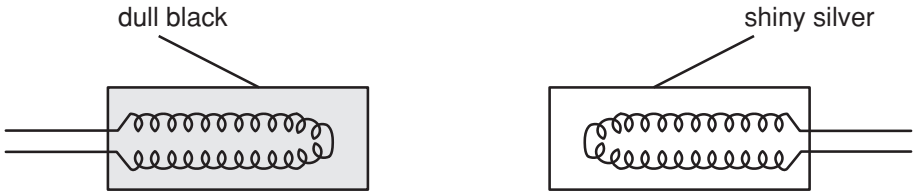


Fig. 5.1

(i) State the additional apparatus needed to test which surface is the best emitter of heat radiation.

.....

(ii) State one precaution that is needed to ensure a fair comparison.

.....

.....

(iii) State the result that you expect.

.....

(iv) Write down another name for heat radiation.

.....
[4]

(b) In the space below, draw a labelled diagram of an everyday situation in which a convection current occurs.

Mark the path of the current with a line and show its direction with arrows. [3]

2 **(a)** Fig. 5.1 shows a copper rod AB being heated at one end.

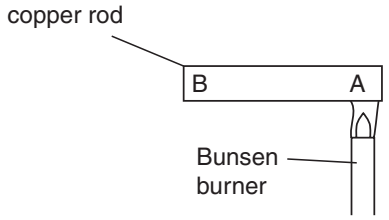


Fig. 5.1

(i) Name the process by which heat moves from A to B.

.....

(ii) By reference to the behaviour of the particles of copper along AB, state how this process happens.

.....

.....

[3]

(b) Give an account of an experiment that is designed to show which of four surfaces will absorb most heat radiation.
The four surfaces are all the same metal, but one is a polished black surface, one is a polished silver surface, one is a dull black surface and the fourth one is painted white.
Give your answer under the headings below.

labelled diagram of the apparatus

readings to be taken

one precaution to try to achieve a fair comparison between the various surfaces

.....

.....[3]

3 **(a)** Four identical metal plates, at the same temperature, are laid side by side on the ground. The rays from the Sun fall on the plates.

One plate has a matt black surface.

One plate has a shiny black surface.

One plate has a matt silver surface.

One plate has a shiny silver surface.

State which plate has the fastest-rising temperature when the sunlight first falls on the plates.

..... [1]

(b) The apparatus shown in Fig. 4.1 is known as Leslie's Differential Air Thermometer.

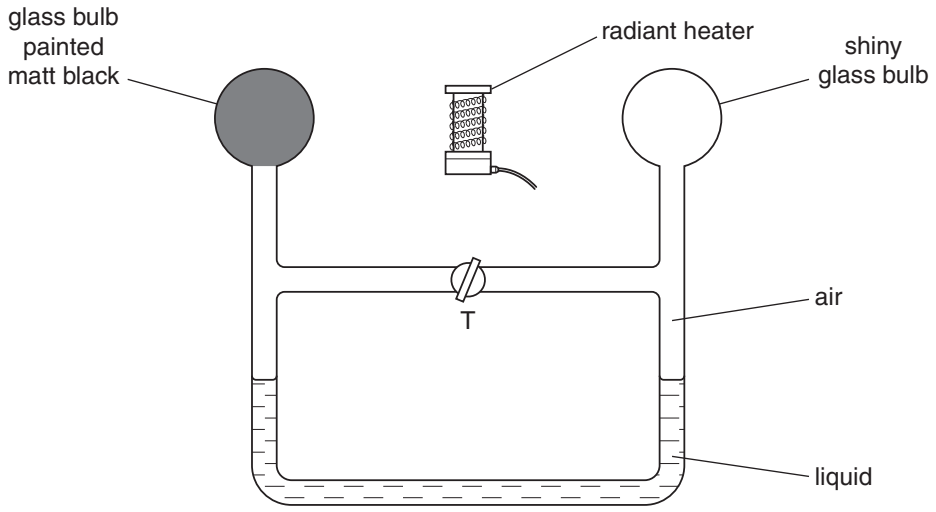


Fig. 4.1

The heater is switched off. Tap T is opened so that the air on the two sides of T has the same pressure. Tap T is then closed.

(i) The heater is switched on. On Fig. 4.1, mark clearly where the two liquid levels might be a short time later. [1]

(ii) Explain your answer to **(b)(i)**.

.....

.....

..... [2]

[Total: 4]

4 A solar panel is mounted on the roof of a house. Fig. 4.1 shows a section through part of the solar panel.

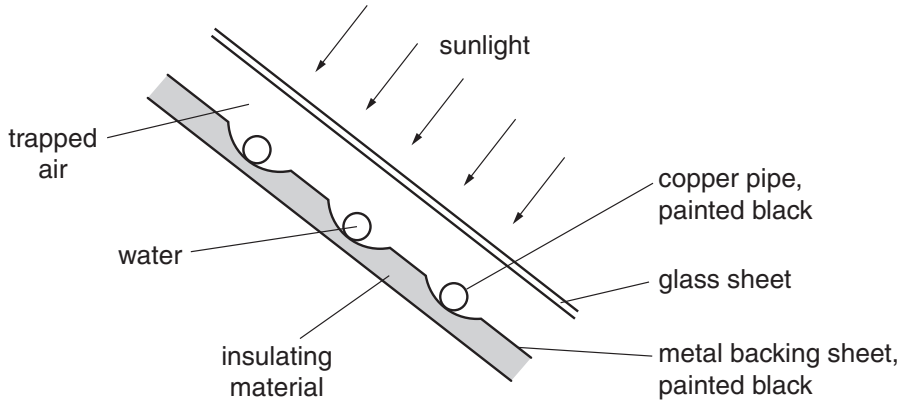


Fig. 4.1

A pump makes water circulate through the copper pipes. The water is heated by passing through the solar panel.

(a) Suggest why

(i) the pipes are made of copper,

.....

..... [1]

(ii) the pipes and the metal backing sheet are painted black,

.....

..... [1]

(iii) an insulating material is attached to the metal backing sheet,

.....

..... [1]

(iv) the presence of the glass sheet increases the energy collected by the water.

.....

..... [1]

(b) During one day, 250 kg of water is pumped through the solar panel. The temperature of this water rises from 16 °C to 38 °C.

The water absorbs 25% of the energy falling on the solar panel, and the specific heat capacity of water is 4200 J/(kg °C).

Calculate the energy falling on the solar panel during that day.

energy = ... [4]

[Total: 8]

5 **(a)** **(i)** Name the process by which [thermal] energy is transferred through a metal rod.

..... [1]

(ii) Describe how this process occurs.

.....

.....

.....

..... [2]

(b) An iron rod and a copper rod of equal length are each held by hand at one end, with the other end in the flame from a Bunsen burner, as shown in Fig. 4.1.

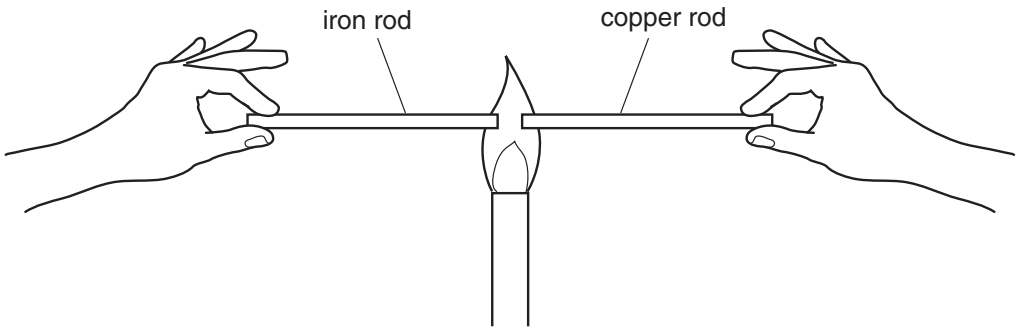


Fig. 4.1

The copper rod becomes too hot to hold much sooner than the iron rod.

What does this information tell you about iron and copper?

..... [1]

(c) Gas has to be above a certain temperature before it burns.

Fig. 4.2 shows two similar wire gauzes, one made of iron wire and one made of copper wire. Each is held over a Bunsen burner. When the gas supply is turned on and ignited below the gauze, the effect is as shown in Fig. 4.2.

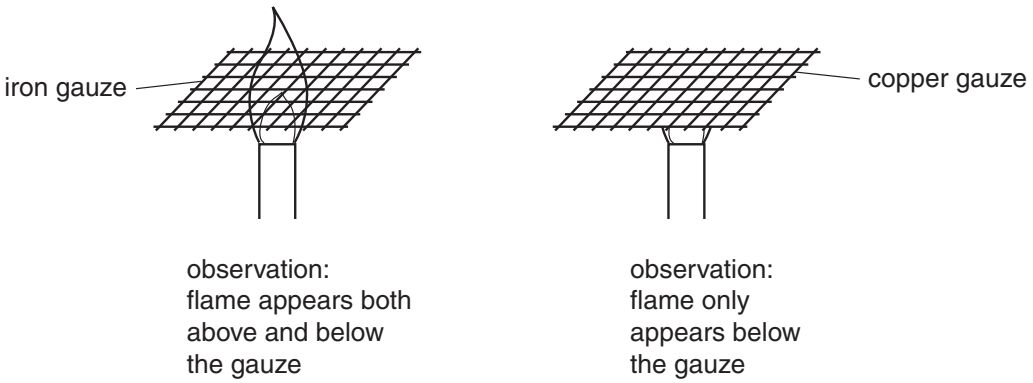


Fig. 4.2

How can these observations be explained?

.....

.....

.....

.....

..... [4]

[Total: 8]

6 Fig. 5.1 shows an X-ray tube.

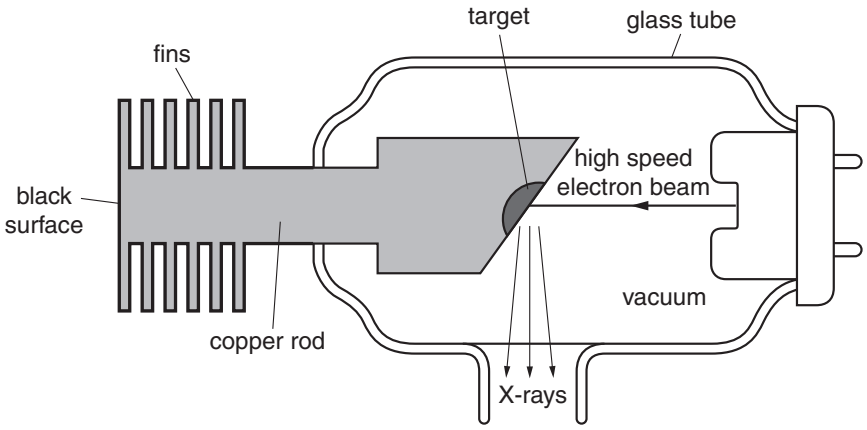


Fig. 5.1

In the production of X-rays, the target gets very hot. Thermal energy must be removed from the target. The tube has several design features to enable this to happen.

For each of the following types of energy transfer, describe how the design of the tube increases the rate of energy transfer. State where the thermal energy transfer mostly happens, the particular design feature that increases the rate of this transfer, and a brief explanation.

(a) conduction

where .....

design feature .....

explanation .....

..... [3]

(b) convection

where .....

design feature .....

explanation .....

..... [3]

(c) radiation

where .....

design feature .....

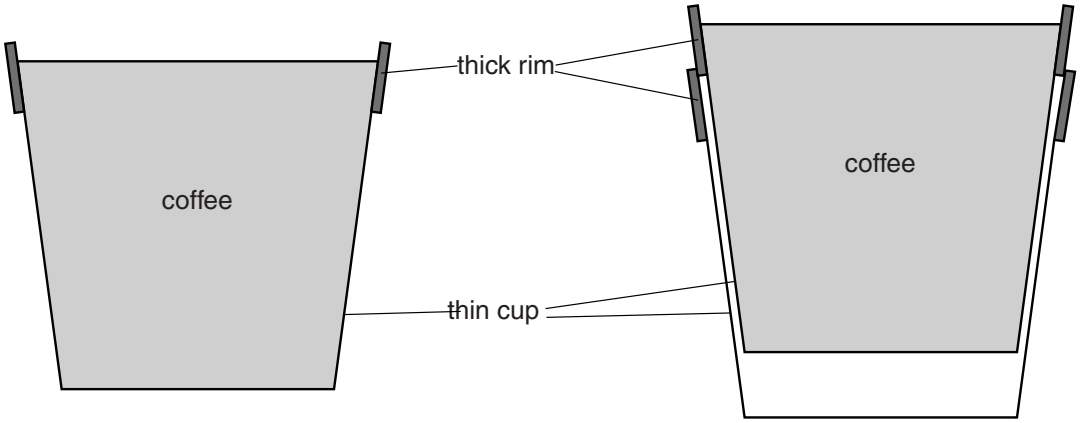
explanation .....

..... [3]

[Total: 9]

7 Fig. 5.1 shows a thin plastic cup containing hot coffee, which an IGCSE Physics student gets from a machine.

Fig. 5.2 shows how another student, who finds an empty second cup, has placed his identical cup of coffee inside this second cup.



single cup

Fig. 5.1

double cup

Fig. 5.2

(a) Suggest and explain a difference that the students will feel when holding the cups.

.....

.....

.....

..... [2]

(b) The students discuss this experience with their teacher, who makes hot drinks the subject of an experiment.

The same volume of hot water at the same temperature is placed in the single cup and in the double cup.

The temperature of the water in each cup is recorded for 10 minutes.

Fig. 5.3 shows the cooling curve for the water in the single cup.

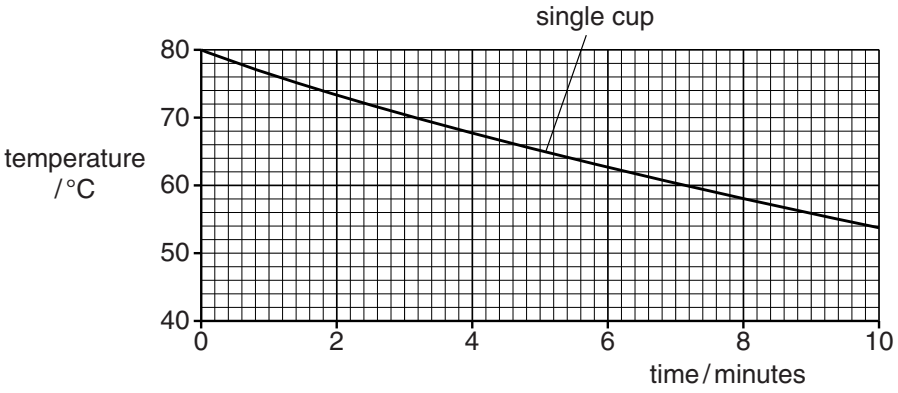


Fig. 5.3

On Fig. 5.3, sketch and label a possible cooling curve for the water in the double cup. [2]

(c) Explain why a cup of coffee cools more slowly when a lid is placed over the cup.

.....

.....

.....

.....

..... [2]

[Total: 6]

8 The water in a copper hot-water tank is heated during the night. During the day, the water cools as thermal energy (heat) passes from the water to the air surrounding the tank.

(a) (i) Describe the process by which the thermal energy is transferred from the hot water to the air.

.....

.....

.....

.....

..... [3]

(ii) State why the rate at which thermal energy passes into the air decreases as the water temperature falls.

.....

..... [1]

(b) The manufacturer of the hot-water tank says that when the outside surface is polished regularly and kept bright and shiny, the hot water will cool more slowly.

Describe, with the aid of a diagram, an experiment that shows whether a container with a bright and shiny surface is better at keeping its contents warm than one with a dull and dark surface.

.....

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..... [4]

[Total: 8]