2.3 Transfer of thermal energy

01. 0625_m23_qp_42 Q: 4

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

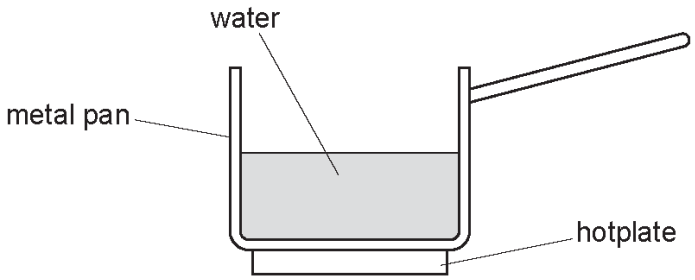

Fig. 4.1

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.

.....

.....

.....

.....

..... [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.

.....

.....

.....

..... [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]

02. 0625_s23_qp_42 Q: 5

(a) Fig. 5.1 shows an electric heater used to heat a room.

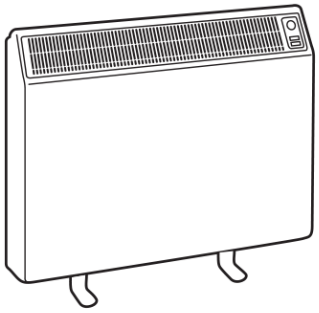

Fig. 5.1

The dimensions of the room are 4.5 m × 6.1 m × 2.4 m.
The density of air is 1.2 kg / m^3.

(i) Show that the mass of air in the room is 79 kg.

[2]

(ii) The power of the heater is 1100 W. The specific heat capacity of air is 1000 J / (kg °C).

Calculate the time taken to increase the temperature of the air in the room from 16.0 °C to 20.0 °C.

time = ... [4]

(iii) Suggest **one** reason why the time calculated in **(a)(ii)** is the **minimum** time needed to increase the temperature of the air in the room from 16.0 °C to 20.0 °C.

.....

..... [1]

(b) Fig. 5.2 shows a cross-section of a double-glazed window in the room.

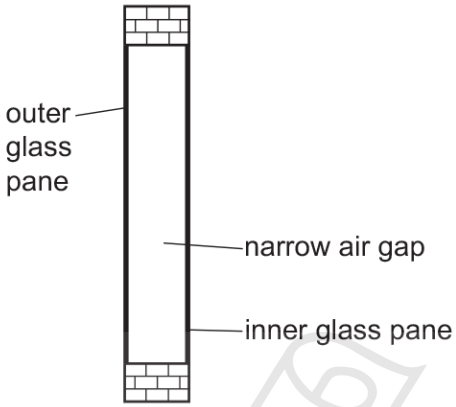

Fig. 5.2

State the main methods of thermal energy transfer from the room to outside which are reduced by this type of window.

..... [1]

03. 0625_w23_qp_41 Q: 2

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

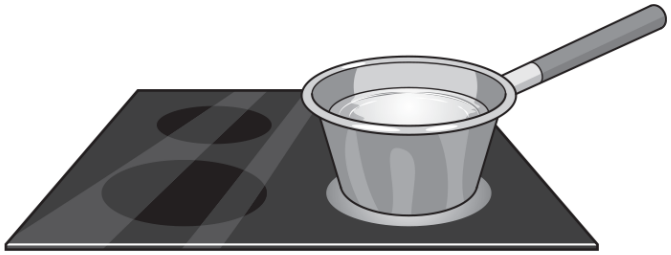

Fig. 2.1

Copper is a metal.

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

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

.....

.....

.....

..... [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.

.....

.....

..... [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]

04. 0625_m22_qp_42 Q: 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.

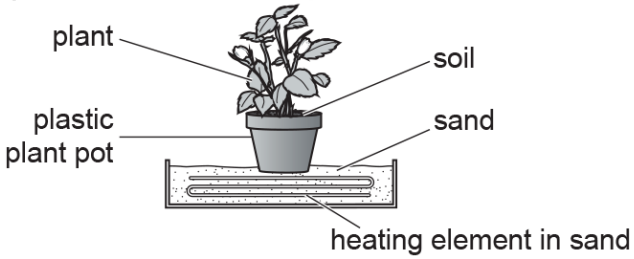

Fig. 4.1

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

.....

.....

.....

..... [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.

.....

.....

..... [2]

---

05. 0625_s22_qp_41 Q: 3

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.

(a) Explain, in terms of molecules, how evaporation cools the water in the cloth.

.....

.....

.....

..... [3]

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

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

.....

.....

.....

..... [3]

---

06. 0625_s22_qp_41 Q: 6

Fig. 6.1 shows a road next to the sea.

Fig. 6.1

(a) On a sunny day, the Sun warms the road.

Describe how energy from the Sun reaches the Earth and warms the road.

.....

.....

.....

..... [3]

(b) The temperature of the road is greater than the temperature of the sea.

The surface of the road is black.

Suggest **one** reason why the temperature of the road is greater than that of the sea.

.....

..... [1]

(c) The air above the road is heated by the warm road.

(i) Describe how this affects the molecules of the air.

.....

.....

..... [2]

(ii) A cyclist travelling along the road notices that a cool breeze is blowing from the sea to the land.

Explain how convection produces this breeze. You may include a diagram if it helps your answer.

.....

.....

.....

..... [3]

07. 0625_w22_qp_42 Q: 5

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

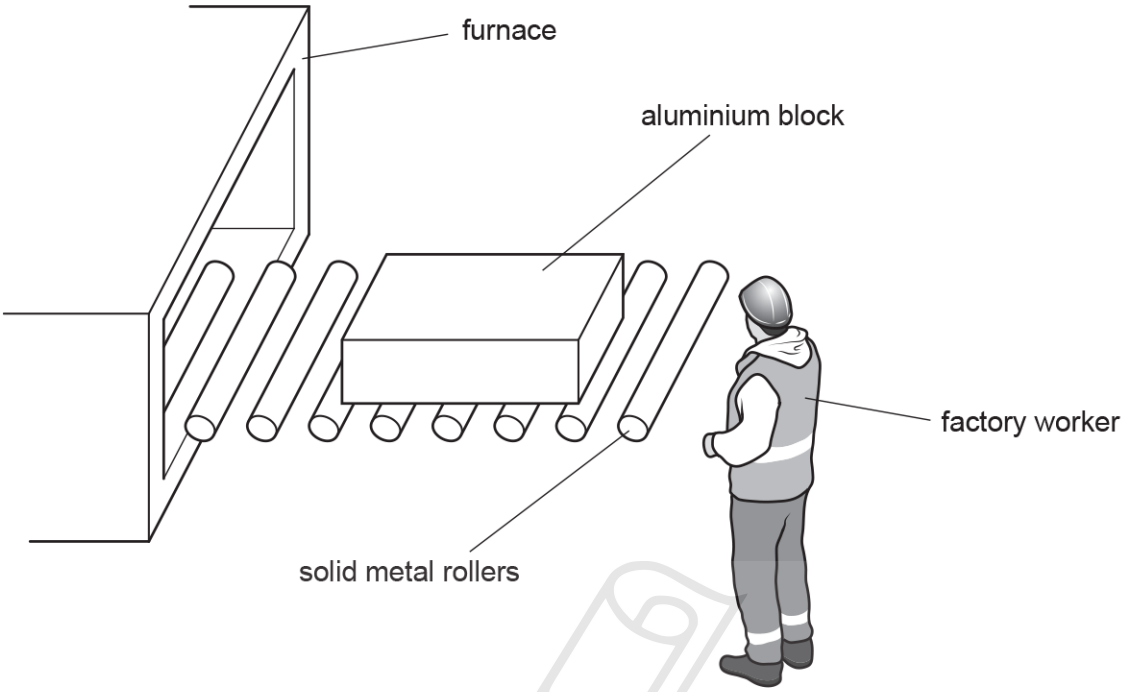

Fig. 5.1

(a) The mass of the block is 1200 kg and it is heated in the furnace from 20 °C to 380 °C. The aluminium block does not melt.
The specific heat capacity of aluminium is 960 J/(kg °C).

Calculate the thermal energy gained by the block in the furnace.

thermal energy = ... [3]

(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.

.....

.....

.....

..... [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.

.....

.....

.....

..... [3]

0625_m21_qp_42 Q: 3

A power station burns waste materials from farm crops to generate electricity.

(a) State and explain whether this process is renewable.

statement .....

explanation .....

.....

[2]

(b) The power station uses some of its waste thermal energy to heat water for houses in a nearby town.

State **one** problem of using waste energy in this way if the power station is far from the town.

.....

Suggest a way of reducing this problem.

.....

.....

[2]

(c) State **two** environmental consequences of burning coal to generate electricity.

consequence 1. .....

consequence 2. .....

[2]

[Total: 6]

---

09. 0625_s21_qp_41 Q: 4
An aluminium saucepan with a plastic handle contains cold water.

Fig. 4.1 shows the saucepan on a hotplate.

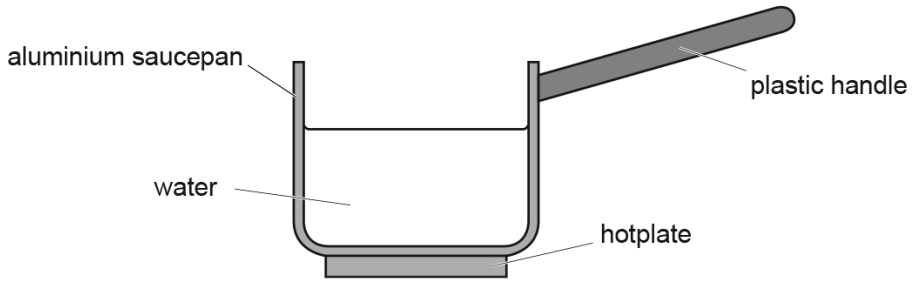

Fig. 4.1

(a) State why the pan is made from aluminium but the handle is made from plastic.

.....

..... [1]

(b) The hotplate is switched on and, as the temperature of the water increases, the internal energy of the water increases.

(i) State, in terms of molecules, what is meant by *an increase in internal energy*.

.....

..... [1]

(ii) Explain, in terms of the atomic lattice and electrons, how thermal energy is transferred through the aluminium.

.....

.....

.....

..... [3]

(iii) Eventually, the water reaches boiling point. Thermal energy from the hotplate is still being transferred to the water.

Explain, in terms of molecules, the effect of this thermal energy on the water.

.....

.....

.....

..... [3]

(iv) The mass of the water decreases by 0.11 kg in 300 s. The specific latent heat of vaporisation of water is 2.3×10^6 J/kg.

Calculate the rate at which the water gains thermal energy.

rate of gain of energy = ... [3]

[Total: 11]

10. 0625_s21_qp_42 Q: 5

(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.

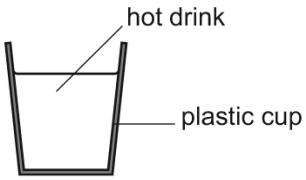

Fig. 5.1

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.

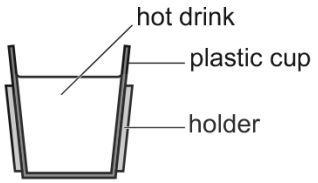

Fig. 5.2a

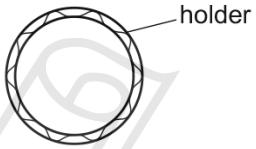

Fig. 5.2b

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]

11. 0625_w21_qp_43 Q: 5

(a) An aluminium saucepan and a steel saucepan have the same dimensions. Table 5.1 shows the values of the specific heat capacity and the density of aluminium and of steel.

Table 5.1

metal	specific heat capacity / J/(kg °C)	density / kg/m^3
aluminium	0.91	2600
steel	0.50	7600

The mass of the aluminium saucepan is 0.41 kg.

(i) Calculate the mass of the steel saucepan.

mass = ... [2]

(ii) Calculate the thermal capacity of the aluminium saucepan.

thermal capacity = ... [2]

(iii) Water is heated in the steel saucepan. The initial temperature of the water and the saucepan is 20 °C.

Calculate the energy transfer needed to raise the temperature of the steel saucepan to 100 °C.

energy = ... [2]

(b) Explain why metals are better thermal conductors than non-metals.

..... [2]

12. 0625_m20_qp_42 Q: 5

(a) Complete the sentences with words that describe the main process of thermal energy transfer in each case.

A man goes for a walk on a cold day. He touches a metal gate, which removes thermal energy from his hands by ..... . He holds the sides of a cup containing a hot drink. His hands gain thermal energy by ..... . Some farm workers have lit a fire. The man warms his hands by the side of the fire. His hands gain thermal energy by ..... . [3]

(b) Describe in terms of particles the transfer of thermal energy through the metal of the gate after transfer from the man's hands.

.....

..... [2]

(c) Fig. 5.1 shows a car on a sunny day in a hot country.

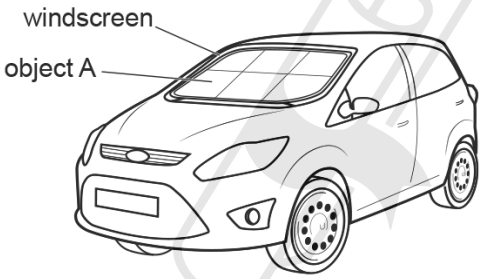

Fig. 5.1

The object labelled A is placed inside the windscreen. It is used by the owner of the car to reduce the temperature rise of the air in the car.

Ring the most suitable material for the outer surface of object A. Explain your choice.

dull black **dull white** **shiny black** **shiny white**

explanation .....

..... [2]

[Total: 7]

13. 0625_w20_qp_41 Q: 5

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.

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

.....

.....

.....

..... [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.

.....

.....

.....

.....

..... [3]

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

Explain the advantage of using a spherical container.

.....

.....

..... [1]

14. 0625_w20_qp_43 Q: 5

Fig. 5.1 shows two metal plates A and B with a radiant heater placed midway between them.

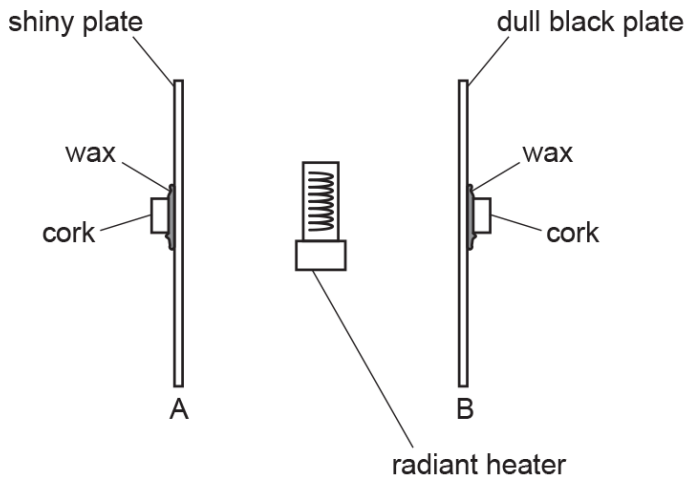

Fig. 5.1

Metal plate A is shiny. Metal plate B is dull black. A piece of cork is attached to each plate using wax. The wax is a solid at room temperature and has a melting point of 37 °C.

(a) State and explain what happens to the pieces of cork a few minutes after the heater is switched on.

.....

.....

.....

.....

..... [4]

(b) Give the name of the method of transfer of thermal energy in solid metals.

..... [1]

15. 0625_m19_qp_42 Q: 6

An electrical heater is placed on the floor of a room in a house. The heater is switched on.

(a) State the main process by which thermal energy is transferred to the air in all parts of the room.

..... [1]

(b) The heater has a power of 1.5 kW. The air in the room has a mass of 65 kg. The specific heat capacity of air is 720 J/(kg °C).

(i) Calculate the time it takes for this heater to raise the temperature of the air in the room from 8.0 °C to 15.0 °C.

time = ... [4]

(ii) State **two** reasons why the time calculated in **(b)(i)** is smaller than the actual time taken to raise the temperature of the air in the room from 8.0 °C to 15.0 °C.

1 .....

.....

2 .....

..... [2]

[Total: 7]

16. 0625_s19_qp_43 Q: 5

Fig. 5.1 shows a cross-section of the inside of a vacuum flask containing a cold liquid. The walls of the vacuum flask are made of glass.

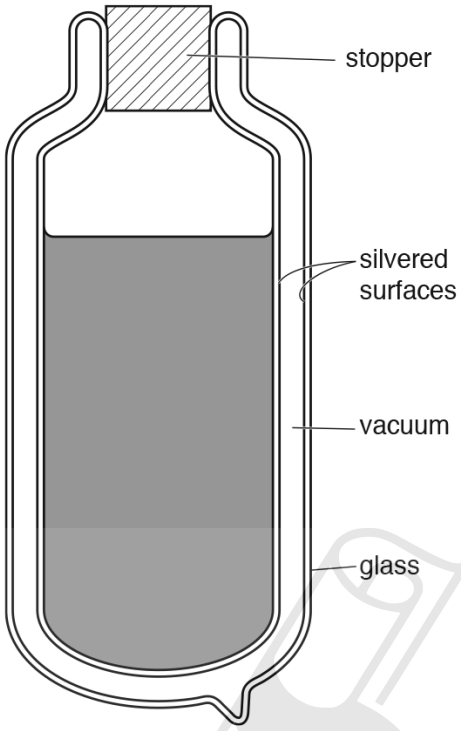

Fig. 5.1

(a) The vacuum flask is being used to keep a liquid cool on a hot day.

Explain how the labelled features of the vacuum flask keep the liquid cool by reducing thermal energy transfer. Include the names of the processes involved.

.....

.....

.....

.....

.....

.....

..... [5]

(b) Suggest a suitable material for the stopper.

..... [1]

[Total: 6]

17. 0625_w19_qp_42 Q: 4

(a) A student carries out an experiment to determine the thermal capacity of a metal block. The block is heated by an electric heater for 23 minutes. The current in the heater is 3.0A at a potential difference (p.d.) of 12V.
The temperature of the block rises from 20°C to 70°C.

Calculate the thermal capacity of the block.

thermal capacity = ... [4]

(b) **1.** Two metal spheres of different diameters are heated to 900°C in a hot oven. The two spheres are removed from the oven.

State and explain any difference in the initial rates of emission of radiation of thermal energy between the two spheres.

.....

.....

.....

2. One hot sphere is now heated in a hotter oven.

State and explain any effect on the rate of emission of radiation of thermal energy from that sphere when it is removed from the hotter oven.

.....

.....

[3]

[Total: 7]

18. 0625_m18_qp_42 Q: 4

Fig. 4.1 shows a cold plastic spoon that has just been placed in hot liquid in a cup.

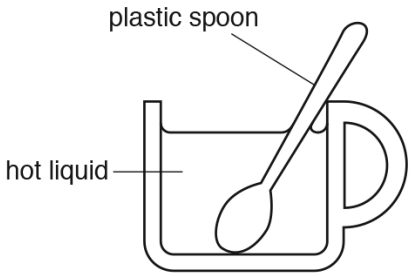

Fig. 4.1

(a) Describe, in terms of molecules, why the temperature of the whole of the spoon increases.

.....

.....

.....

.....

..... [3]

(b) The plastic spoon is replaced by a metal spoon.

Describe an additional process by which the temperature of the whole of this spoon increases.

.....

.....

..... [2]

(c) The cup contains 150 g of liquid of specific heat capacity 4.2 J/(g °C). When the cold spoon is placed into the hot liquid, the temperature of the liquid decreases from 80 °C to 56 °C.

Calculate the loss of thermal energy from the liquid.

energy loss = ... [3]

[Total: 8]

19. 0625_s18_qp_42 Q: 5

A student wants to investigate good and bad absorbers of thermal radiation. She has the apparatus shown in Fig. 5.1, a supply of cold water and a metre rule.

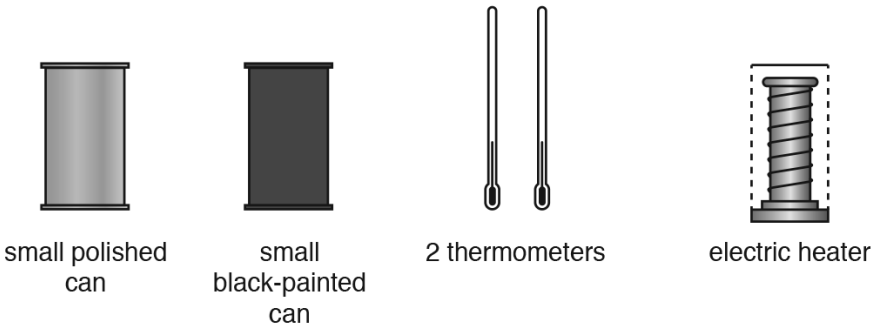

Fig. 5.1

Explain how the student could use the apparatus she has available to carry out her investigation. Describe the results she would expect to obtain. Draw a diagram of the set-up.

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 4]

20. 0625_s18_qp_43 Q: 4

A beaker contains some water at room temperature. A student places a mercury-in-glass thermometer in the water with the bulb of the thermometer just beneath the surface of the water.

Fig. 4.1 shows the arrangement.

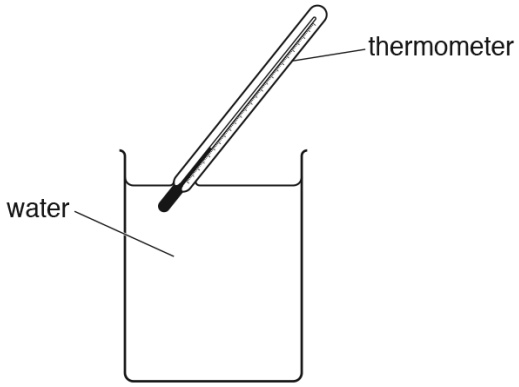

Fig. 4.1

The student uses an electric fan to blow air across the open top of the beaker. She notices that the reading on the thermometer begins to decrease.

(a) Explain, in terms of water molecules, why the temperature of the water at the surface begins to decrease.

.....

.....

.....

.....

.....[3]

(b) The student places the thermometer near the bottom of the beaker. The electric fan continues to blow air across the top of the beaker. After some time, the student observes that the temperature of the water at the bottom of the beaker is decreasing.

State the name of the thermal transfer method causing this and explain what is happening in the water.

.....

.....

.....

.....

.....[3]

(c) The thermometer used in this experiment has a small range and a large sensitivity.

(i) State what is meant by

1. *range*,

.....

.....[1]

2. *sensitivity*.

.....

.....[1]

(ii) State and explain the effect on the range of the thermometer of using a smaller bulb that contains less mercury.

.....

.....[1]

[Total: 9]

21. 0625_m17_qp_42 Q: 4

Fig. 4.1 shows a Galilean thermometer. This thermometer is used to measure the approximate temperature of the surrounding air.

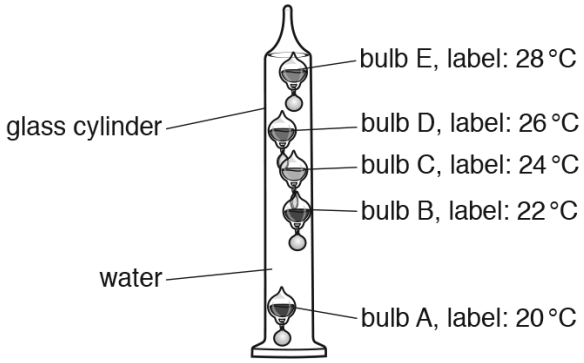

Fig. 4.1

The glass cylinder contains water. When the temperature of the water changes, so does its density.

Each bulb has a label printed with a temperature, as shown in Fig. 4.1. The bulbs have different densities. At 21 °C, only bulb A is at the bottom of the cylinder.

(a) Explain, in terms of density, why bulb A is at the bottom of the cylinder and the other bulbs are floating.

.....

.....

.....

.....[2]

(b) The temperature of the surrounding air increases to a temperature above 23 °C.

(i) Suggest **one** reason why there is a delay before the temperature of the water increases to 23 °C.

.....[1]

(ii) Explain why, after this delay, bulb B sinks. Assume the bulbs do not expand.

.....

.....

.....

.....[3]

(c) Bulbs A, B and C are now at the bottom of the cylinder. Bulbs D and E are floating.

State the possible temperature range of the water in the cylinder.

.....[1]

[Total: 7]

22. 0625_m17_qp_42 Q: 6

Fig. 6.1 shows apparatus that is used to demonstrate some effects of the transfer of energy by radiation.

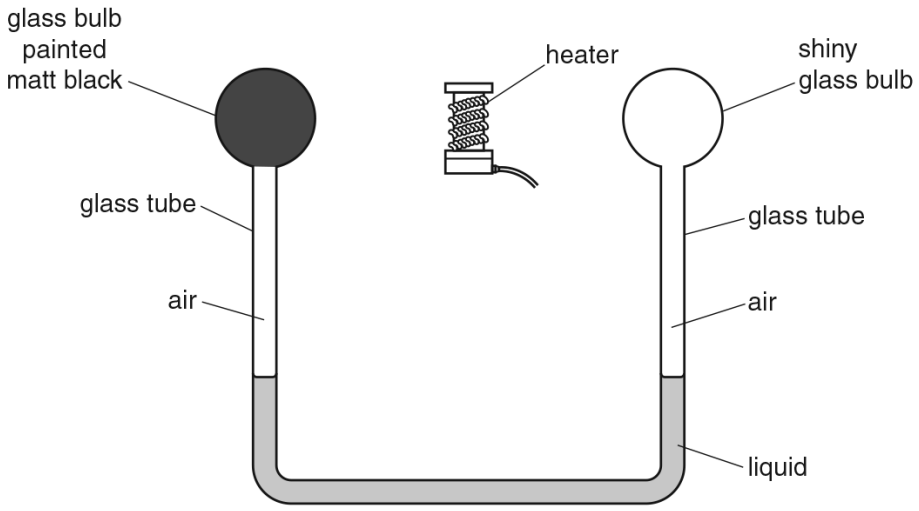

Fig. 6.1

The glass bulb painted matt black, the shiny glass bulb and the spaces above the liquid in the tube all contain air.

The heater glows red when switched on. The heater is the same distance from each bulb.

(a) State the **two** types of radiation that are emitted by the heater.

1 .....

2 .....

[1]

(b) Before the heater is switched on, the liquid levels in the glass tube are the same.

State and explain any changes in the liquid levels that take place when the heater is switched on.

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 5]

23. 0625_s17_qp_41 Q: 4

(a) A 240 V, 60 W lamp is connected to a 240 V supply. The lamp has a constant temperature.

State

(i) the rate at which the lamp transfers energy to the surroundings,

rate = ...[1]

(ii) the names of the thermal processes by which the lamp transfers energy to the surroundings.

.....

.....[1]

(b) Fig. 4.1 shows a thick copper block that has been heated to 400 °C. One side of the block is dull black. The other side of the block is polished and shiny.

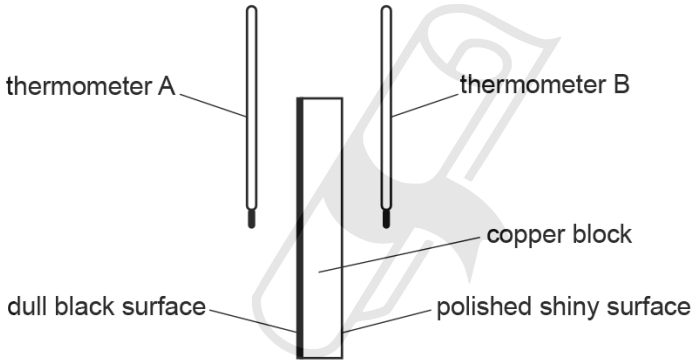

Fig. 4.1

(i) In Experiment 1, the thermometer bulbs are both painted black. They are placed at equal distances from the surfaces of the block. The maximum temperature shown by each thermometer is recorded.

Explain any difference between the maximum temperature shown by the two thermometers.

.....

.....

.....

.....[3]

(ii) In Experiment 2, the thermometer bulbs are both shiny silver-coloured. They are placed at the same distances from the surfaces of the block as in Experiment 1.

State and explain any differences that are observed in the maximum temperatures shown by the thermometers in Experiments 1 and 2.

.....

.....

.....

.....

.....[2]

Fig. 4.2 shows a firefighter wearing shiny silver-coloured clothing.

Fig. 4.2

State the benefit to a firefighter of wearing shiny silver-coloured clothing.

.....

.....[1]

[Total: 8]

24. 0625_s17_qp_42 Q: 5

(a) (i) An electric kettle contains 600 g of water at 20 °C. The heater in the kettle operates at 240 V. The specific heat capacity of water is 4200 J/(kg °C).

The current in the heater is 12 A.

Calculate the time taken for the temperature of the water to rise to 100 °C.

time = ...[4]

(ii) State **one** assumption you made in your calculation in **(a)(i)**.

.....[1]

(b) Using the apparatus shown in Fig. 5.1, describe an experiment to demonstrate good and bad emitters of thermal radiation. Include the expected results and the conclusion.

You may use a diagram.

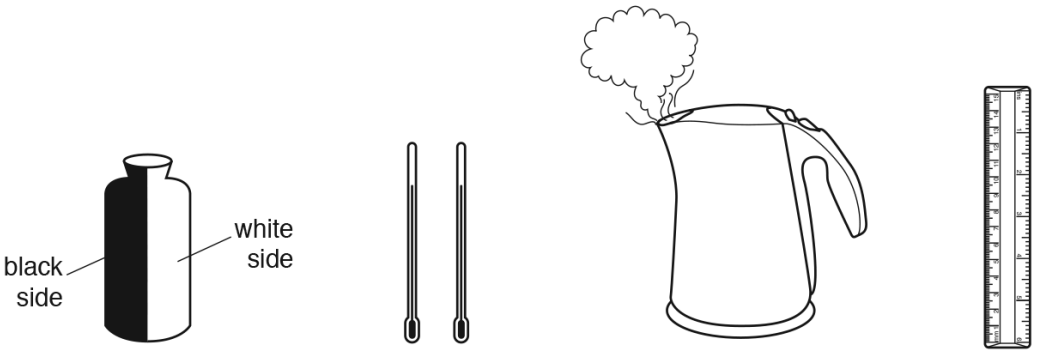

Fig. 5.1

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 9]

25. 0625_s17_qp_43 Q: 5

A footballer and a referee are discussing a puddle of water that has formed on the pitch. The footballer wears a white shirt whilst the referee wears a black shirt which, apart from its colour, is identical.

Fig. 5.1 shows the two men looking at the puddle.

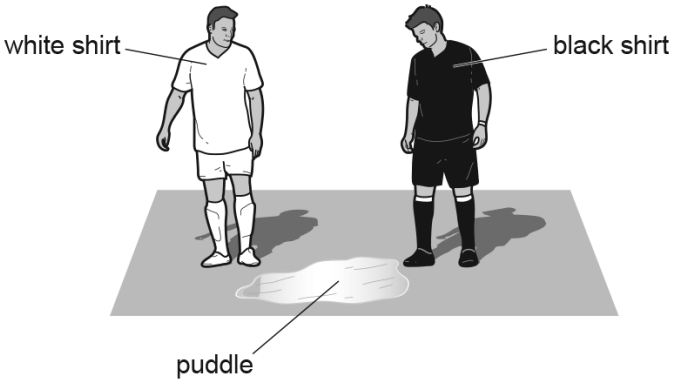

Fig. 5.1

The weather is bright and sunny.

(a) State and explain how the temperature of the white shirt differs from the temperature of the black shirt.

.....

.....

.....[2]

(b) The volume of water in the puddle is slowly decreasing.

(i) Describe how **two** changes in the weather conditions could affect the rate at which the puddle dries.

change 1 .....

effect .....

.....

change 2 .....

effect .....

.....

[2]

(ii) Explain, in terms of the water molecules, what happens as the puddle dries.

.....

.....

.....[2]

[Total: 6]

---

26. 0625_w17_qp_42 Q: 5

(a) Explain why houses in hot countries are often painted white.
Use ideas about the transfer of thermal energy in your answer.

.....

.....

.....

.....[3]

(b) As a star approaches the end of its life, the amount of radiation emitted from it per second changes.

The star cools down.
State any effect on the rate of emission of radiation.

.....

.....[1]

[Total: 4]
