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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Transfer of Thermal Energy

Paper 2 — Theory / Structured Questions (topical compilation)

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M.Eng NUS Singapore · B.Eng NUST · 15+ years of teaching experience in Singapore, UAE & Pakistan · 60,000+ subscribers and 20 million+ video lecture views.

1 A student compares the efficiency of two electric water heaters in the kitchen. Each heater consists of a tank to contain the water and an electrical heating element to heat the water.

The two tanks are different, but each tank contains the same amount of water and is heated by the same type of electrical heating element.

Fig. 10.1 shows part of the tank from the heater that is less efficient, and Fig. 10.2 shows the heater that is more efficient.

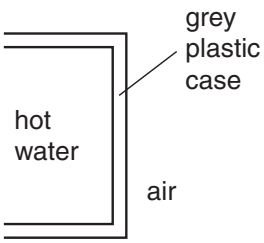

Fig. 10.1

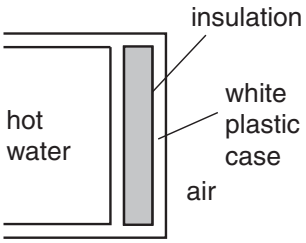

Fig. 10.2

(a) Energy is lost by **conduction**, **convection** and **radiation** from each water heater.

(i) Describe what happens to the molecules of the plastic case in Fig. 10.1 during **conduction**.

(ii) Describe what happens to the molecules of the air outside the heater in Fig. 10.1 during **convection**.

[2]

(b) **(i)** Explain how the more efficient heater in Fig. 10.2 reduces the energy lost by conduction, convection and radiation.

(ii) State two advantages of using an efficient water heater in a kitchen.

[5]

5054/02/M/J/03/Q10

2 Heat is transferred by conduction, convection and radiation.

(a) **(i)** State which of the three methods is responsible for the transfer of heat from the Sun to the Earth.

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(ii) Explain why the other two methods cannot be involved in this transfer.

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[2]

(b) A hand feels hot when placed above a lighted match, as shown in Fig. 2.1.
Explain in detail how convection causes this to happen.

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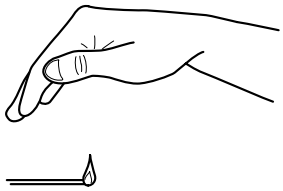

Fig. 2.1 [2]

(c) Fig. 2.2 shows a layer of fibreglass placed between the ceiling of a room and the roof of a house.

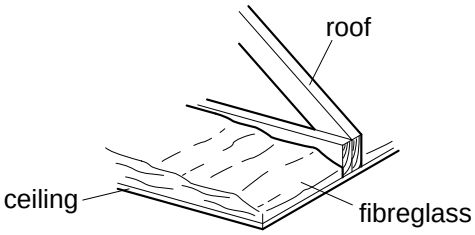

Fig. 2.2

Explain how the layer of fibreglass helps to keep the room warm when it is cold outside.

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.....[2]

5054/02 M/J/04/Q2

3 Fig. 9.1 shows the main parts of an electric grill. An electric current in the heating element causes it to become red hot and to emit visible light and infra-red radiation. The infra-red radiation is used to cook food.

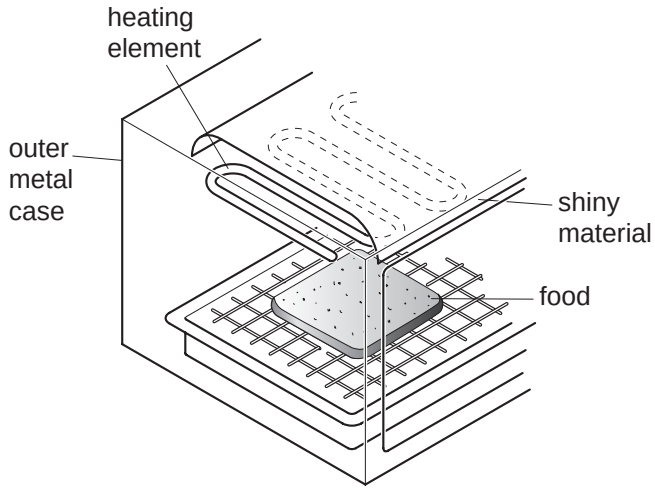

Fig. 9.1

(a) Infra-red radiation has a longer wavelength than visible light. Both are parts of the electromagnetic spectrum.

(ii) Explain why the grill has a layer of shiny material between the heating element and the outer case.

[2]

5054/02 M/J/04/Q9

4 When a house is heated, energy is lost to the outside.

Fig. 10.1 shows where the energy is lost from the house.

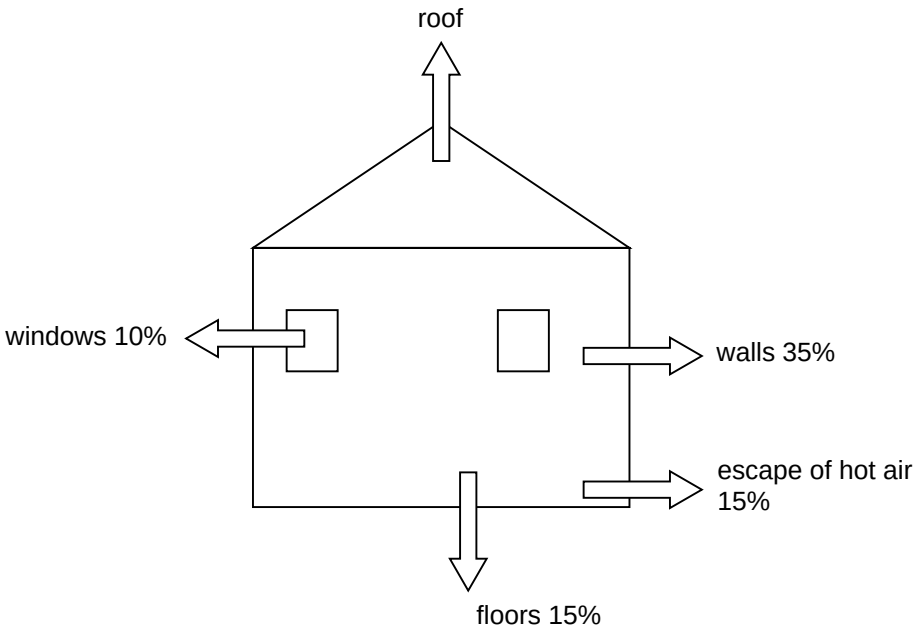

Fig. 10.1

(a) **(i)** Calculate the percentage of the energy lost through the roof. [1]

(ii) Energy is lost through the roof by conduction and from the roof by convection and by radiation. Explain in detail how this happens. [6]

(iii) Fitting carpets on the floor reduces energy loss. Explain how a carpet reduces energy loss. [2]

(b) The table gives information about three methods of reducing energy loss.

	method of reducing energy loss	installation cost	saving on energy costs in one year	number of years of saving needed to cover installation costs
A	fitting carpets on the floor	$600	$10	60
B	insulating the roof	$300	Y	3
C	fitting modern windows	X	$20	40

(i) Calculate the values of X and Y. [2]

(ii) Which one of these three methods should the house owner choose? Explain your answer. [2]

(iii) State **two** other ways, not already mentioned, of reducing energy loss from the house. [2]

5054/02/M/J/05/Q10

5 During a marathon race, the runner shown in Fig. 3.1 is very hot.

Fig. 3.1

At the end of the race, evaporation and convection cool the runner.

(a) **(i)** Explain how evaporation helps the runner to lose energy. Use ideas about molecules in your answer.

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..... [2]

(ii) Explain why hot air rises around the runner at the end of the race.

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..... [1]

(b) At the end of the race, the runner is given a shiny foil blanket, as shown in Fig. 3.2. Wearing the blanket stops the runner from cooling too quickly.

Fig. 3.2

Explain how the shiny foil blanket helps to reduce energy losses.

Use ideas about conduction, convection and radiation in your answer.

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..... [3]

5054/02/M/J/08/Q3

6 Fig. 2.1 shows a metal pan containing water on a cooker. The hotplate heats the water.

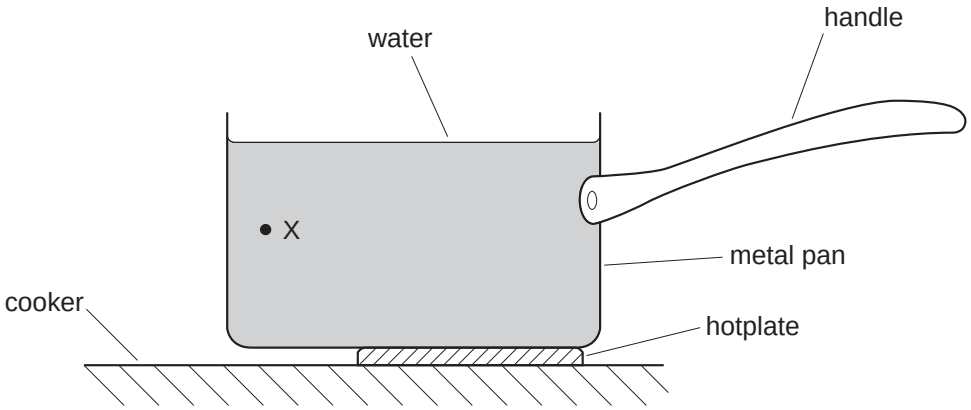

Fig. 2.1

(a) (i) State the method of heat transfer through the metal pan.

..... [1]

(ii) Describe how the molecules transfer heat through the metal pan.

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.....

..... [1]

(b) (i) On Fig. 2.1, draw an arrow to show the direction of movement of the water at point X. [1]

(ii) Explain why the water moves in this direction.

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..... [3]

5054/02/M/J/09/Q2

7 Fig. 3.1 shows a metal roof. One side is facing the Sun.

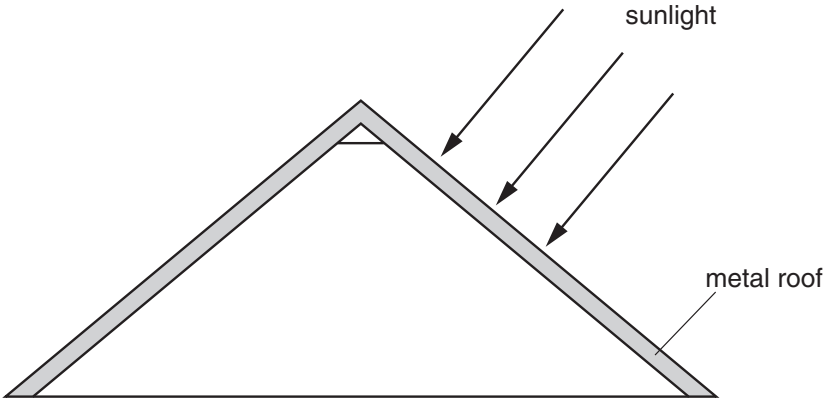

Fig. 3.1

(a) State the means by which thermal energy (heat) is transferred from the Sun to the Earth and explain why other means of thermal energy transfer are not involved.

.....

..... [2]

(b) Describe how thermal energy is transferred through the metal roof from the heated surface.

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..... [2]

5054/22/M/J/10/Q3

8 Fig. 3.1 shows the plan of a bedroom and part of the main room of a house. Other rooms are not shown.

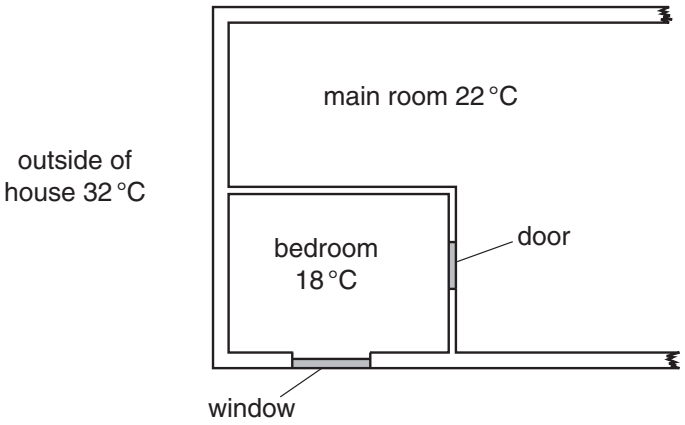

Fig. 3.1

The temperatures of the main room, the bedroom and the outside of the house are shown on Fig. 3.1.

Fig. 3.2 shows all the thermal energy (heat) inputs to the bedroom in one hour.

thermal energy input to bedroom	
through door and walls from main room	50 000 J
through walls from outside of house	2 000 000 J
through window	1 000 000 J
from person sleeping in bedroom	250 000 J

Fig. 3.2

(a) Suggest why more thermal energy enters the bedroom from the outside of the house than from the main room.

.....[1]

(b) An air conditioner keeps the temperature constant in the bedroom by removing thermal energy.

(i) Calculate the total thermal energy that the air conditioner removes from the bedroom in one hour.

thermal energy = ...[1]

(ii) The electrical power input to the air conditioner is 300 W.
Calculate the electrical energy input into the air conditioner in 1 hour.

energy = ...[2]

(c) The air conditioner cools the air at the top of the room. This causes a convection current in the room.

Explain how the cold air gives rise to the convection current.

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.....[3]

5054/22/M/J/12/Q3

9 A student places a small electrical heater inside a cup of water, as shown in Fig. 11.1.

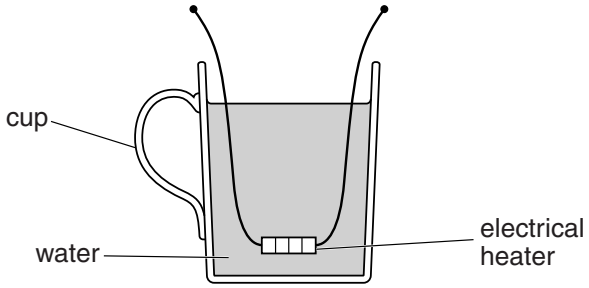

Fig. 11.1

(d) The student turns off the power supply and the water cools.

Describe and explain how convection in the air causes the water to cool.

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..... [2]

5054/22/M/J/13/Q11

10 Two metal saucepans contain the same mass of hot water at the same initial temperature.
Pan A is white and pan B is black, but otherwise the two saucepans are identical.
Both saucepans are uncovered and cool under the same conditions.
The cooling curves for the two saucepans are shown in Fig. 10.1.

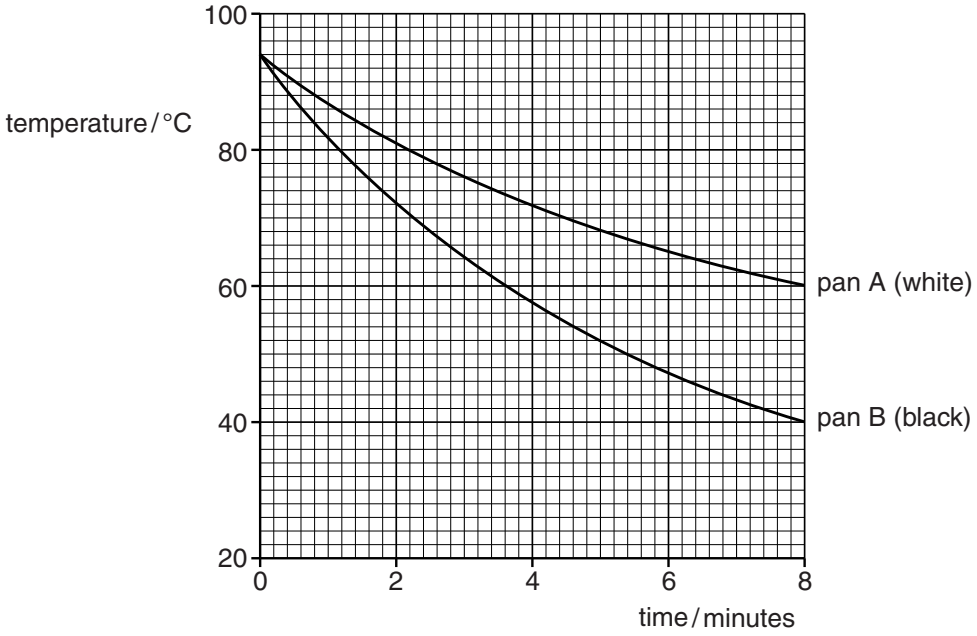

Fig. 10.1

(a) Describe how the water in a pan loses heat by

(i) conduction,

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..... [2]

(ii) convection.

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..... [2]

(b) **(i)** Explain why pan B cools faster than pan A.

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..... [1]

(ii) Describe and explain how Fig. 10.1 is different when the pans are covered and the experiment is repeated.

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..... [2]

5054/22/M/J/14/Q10

11 **(c)** The beaker shown in Fig. 10.2 contains pure water at a temperature of 80 °C. A thermometer, initially at room temperature, is placed in the air just above the water.
The reading on the thermometer starts to increase slowly.

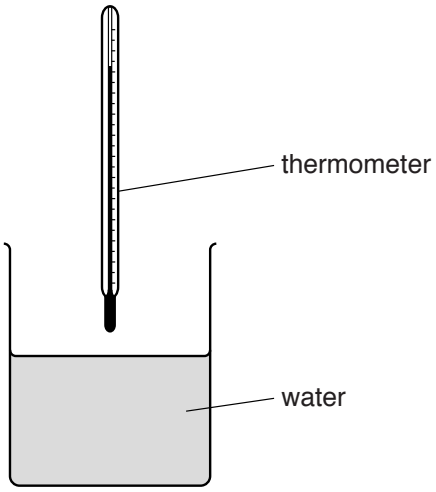

Fig. 10.2

(i) Explain how convection in the air causes the reading on the thermometer to increase.

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.....[1]

(ii) A heater is placed underneath the beaker and the water boils vigorously to produce steam. The thermometer reading increases quickly.

Explain how the water in the gas state gives thermal energy (heat) to the thermometer.

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.....[2]

5054/21/M/J/15/Q10

12 (b) The boiling point of nitrogen is –196 °C.

Liquid nitrogen, below its boiling point, is stored in a vacuum flask, as shown in Fig. 10.1.

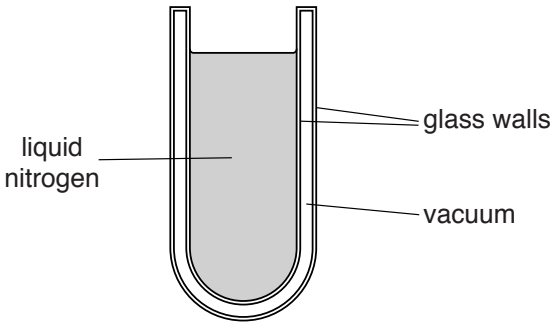

Fig. 10.1

The flask has two glass walls with a vacuum between them.

(i) Suggest where, in the apparatus shown in Fig. 10.1, evaporation occurs.

.....[1]

(ii) State and explain the advantage of having a vacuum between the two glass walls.

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.....[3]

5054/21/M/J/16/Q10

13 Fig. 3.1 shows a metal coffee cup on a metal warming plate.

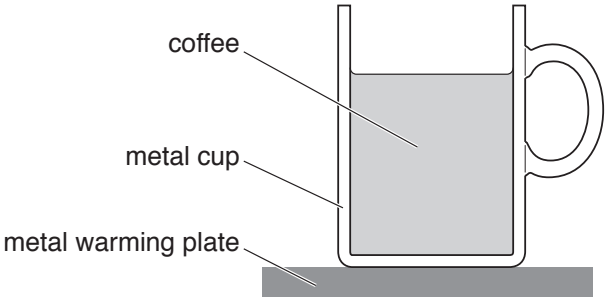

Fig. 3.1

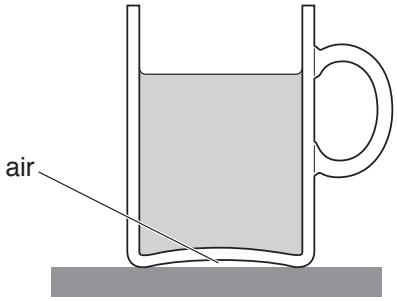

Fig. 3.2

There is a small electrical heater inside the warming plate that keeps the plate hotter than the coffee.

(a) Describe how heat is transferred through the metal and then to all of the liquid in the cup.

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.....[3]

(b) A cup of a different shape is placed on the same heater, as shown in Fig. 3.2. The two cups are made of the same metal and contain the same amount of coffee.

Explain why the coffee in the cup in Fig. 3.2 is not kept as warm as the coffee in the cup in Fig. 3.1.

.....

.....[1]

(c) The outside surface of the cup can be either black or white and can be either dull or shiny.

(i) Underline which colour **and** which type of surface is best to keep the coffee warm.

black **white** **dull** **shiny** [1]

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

.....

.....
[1]

5054/21/M/J/17/Q3

14 Fig. 10.1 is a diagram of a soldering iron. Solder is a mixture of metals used to make a permanent contact between electrical wires.

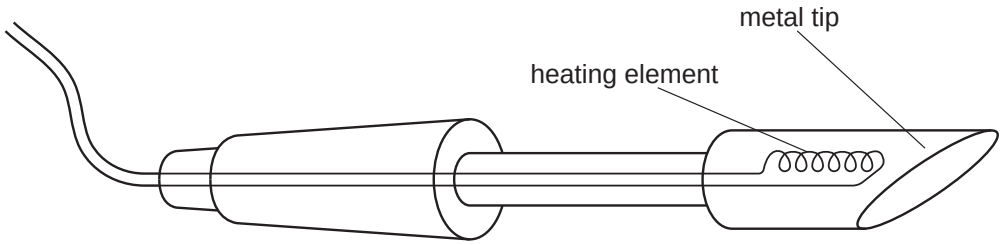

Fig. 10.1

The heating element raises the temperature of the metal tip. When solder is placed against the tip, the solder melts over the wires to be joined. When the solder cools, it solidifies and the permanent connection is made.

The working temperature of the metal tip is 380 °C.

(c) **(i)** Describe, in terms of free electrons, the process by which heat transfers through the metal tip.

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..... [2]

(ii) Heat is lost from the metal tip by convection in the air.

Explain how convection occurs in the air.

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..... [2]

5054/22/M/J/19/Q10

15 Glass and iron are both conductors of heat. However, glass is a poor conductor of heat and iron is a good conductor of heat.

(a) Describe, using ideas about particles, how the conduction of heat takes place in glass and in iron. You should make it clear why iron is a better conductor of heat.

conduction in glass .....

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conduction in iron .....

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[4]

(b) Fig. 4.1 shows apparatus used to show expansion.

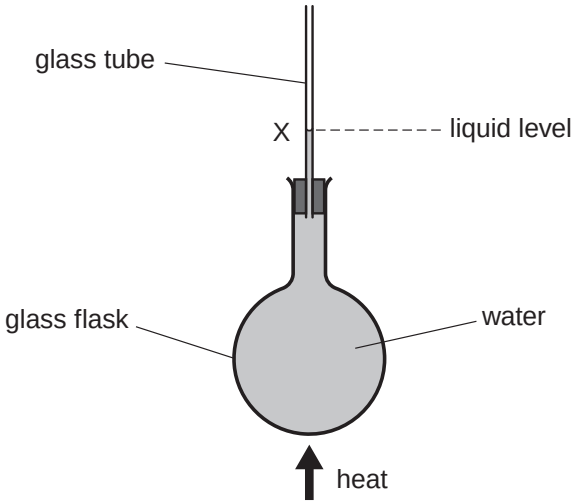

Fig. 4.1

The glass flask, full of water, is heated. A student is surprised when the liquid level X in the glass tube falls for a few seconds before it rises.

(ii) Describe how heat is transferred throughout the water in the glass flask.

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..... [2]

5054/21/M/J/20/Q4

16 (b) Fig. 5.1 shows a microwave oven used to heat soup. The container for the soup is a glass bowl.

Microwaves created inside the oven are reflected by the metal walls.

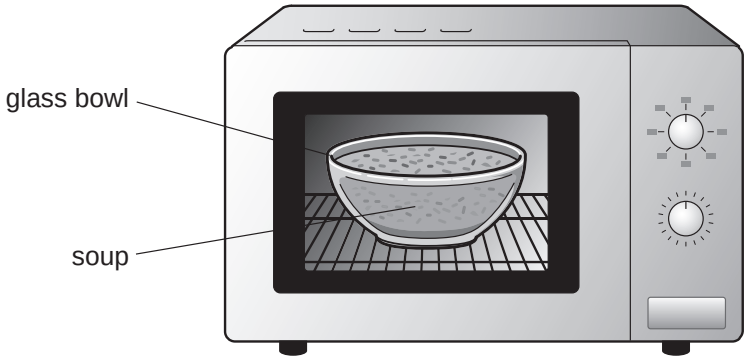

Fig. 5.1

(i) Explain why the choice of material for the container is important in microwave cooking.

.....

..... [1]

(ii) The soup is mostly water.

Microwaves are completely absorbed by a few centimetres of water.

As a result, microwaves do not reach the centre of the soup.

The instructions suggest that, after the microwave oven is turned off, the soup:

- is not stirred
- is left for some minutes so that the centre becomes hot.

State the name of and describe each of the **two** processes by which thermal energy transfers throughout the soup after the microwave oven is turned off.

name of first process .....

description .....

.....

.....

name of second process .....

description .....

.....

..... [3]

5054/22/M/J/20/Q5

17 Fig. 2.1 shows a hollow metal cube filled with boiling water. The temperature of the four vertical surfaces are equal but each surface has a different colour or texture.

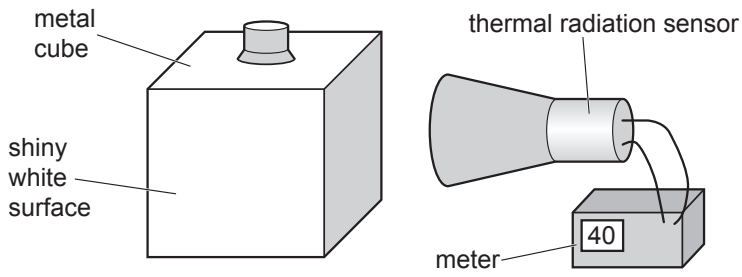

Fig. 2.1

A thermal radiation sensor is placed the same distance from each surface and the meter reading measures the thermal radiation emitted from each surface.

(a) The results are shown in **Fig. 2.2**.

Draw a line linking each type of surface with the appropriate meter reading. One line has been drawn for you.

type of surface	meter reading
dull black	40
dull white	60
shiny black	80
shiny white	100

Fig. 2.2

[2]

(b) The hot surfaces produce a convection current in the air outside the metal cube.

Describe how the convection current is produced.

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..... [3]

5054/21/M/J/21/Q2

18 Fig. 5.1 shows the boiler of a coal-fired power station. Hot gases rise and thermal energy warms the water inside the metal pipes.

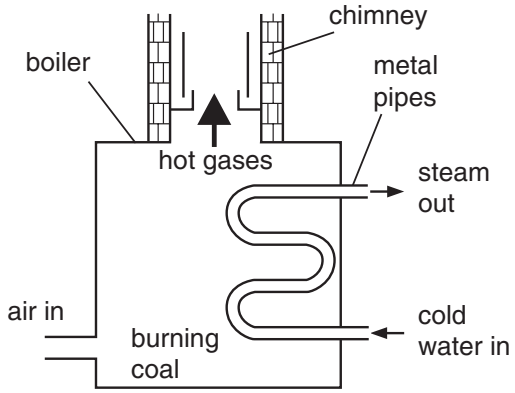

Fig. 5.1

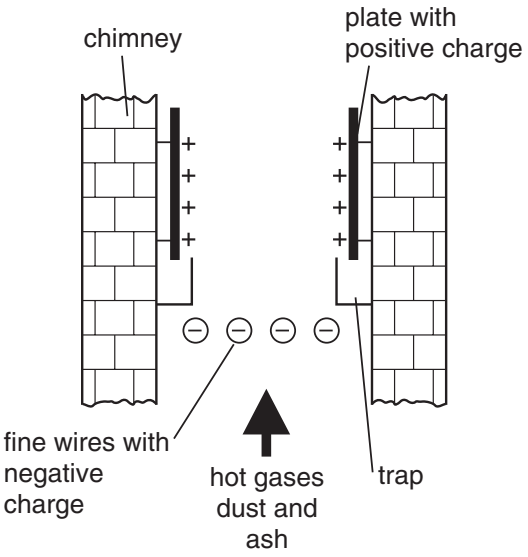

Fig. 5.2

(a) **(i)** Explain why the hot gases rise.

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(ii) Explain how energy passes through the metal pipes by conduction. Use your ideas about particles.

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[3]

(b) Fig. 5.2 shows an electrostatic precipitator that stops dust and ash emerging from the chimney.

Explain how the precipitator works.

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.....[3]

5054/2/O/N/02Q5

19 Fig. 9.1 shows a refrigerator.

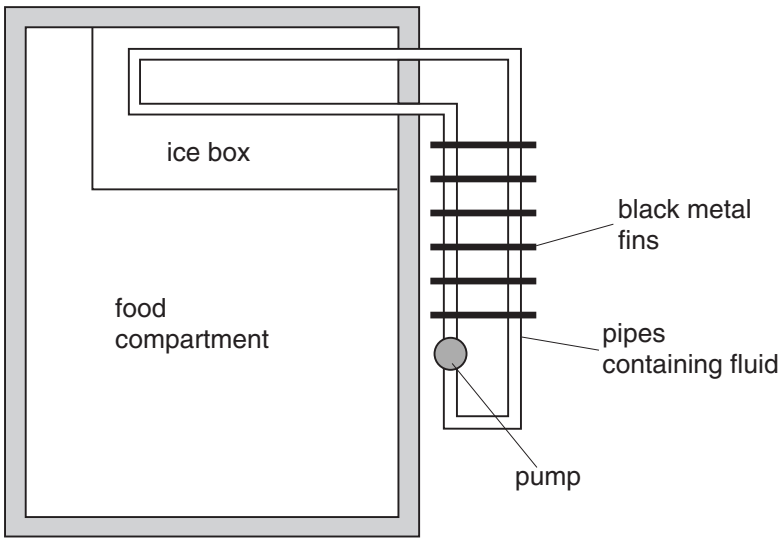

Fig. 9.1

Inside the pipes in the ice-box, a liquid boils and takes in latent heat. The gas condenses in the pipes at the back of the refrigerator and thermal energy (heat) leaves through the black metal fins.

(b) **(i)** Explain how the ice box at the top of the refrigerator keeps the whole of the food compartment cool.

(ii) Explain why the fins are black.

[4]

5054/02/O/N/03/Q9

20 A heat pipe is a device that transmits thermal energy along its length. It can transmit energy thousands of times faster than a solid copper rod. Fig. 8.1 shows a heat pipe attached to black metal fins. The fins absorb energy from the Sun. The sealed pipe transmits this energy along its length into a tank of cold water.

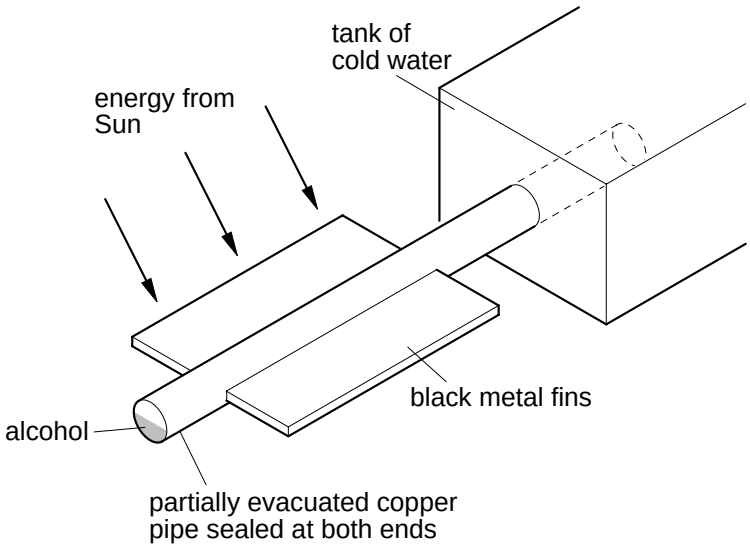

Fig. 8.1

Thermal energy from the fins is conducted through the walls of the copper pipe and causes the alcohol to boil. The boiling creates a higher pressure. At the end of the copper pipe in contact with cold water, the alcohol condenses and creates a lower pressure. The liquid alcohol runs along the pipe to be boiled again. There is little change in the temperature of the alcohol.

(a) **(i)** Describe how molecules in the copper conduct energy to the alcohol.

(ii) Explain how boiling and condensation within the heat pipe cause the transfer of energy.

(iii) Explain why the heat pipe is able to transfer energy at a fast rate.

[4]

(c) Black surfaces absorb and emit infra-red radiation better than white surfaces.

(i) Describe an experiment that shows black surfaces absorb radiation better than white surfaces.

(ii) Describe an experiment that shows black surfaces emit radiation better than white surfaces at the same temperature.

[5]

054/02 O/N/04/Q8

21 Three horizontal rods are placed with one end just above a Bunsen flame. The other end of each rod is coated with wax, as shown in Fig. 3.1.

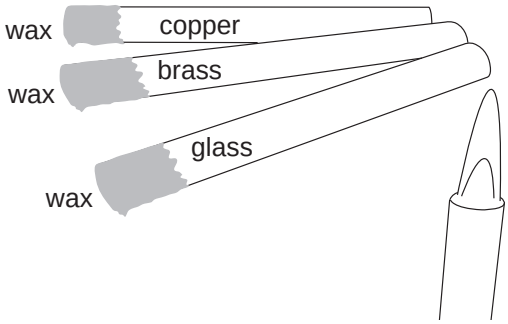

Fig. 3.1

(a) Describe how you would use the apparatus to discover which rod is the best conductor of heat.

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..... [2]

(b) Two metal teapots are identical except that one is black on the outside and the other is white on the outside, as shown in Fig. 3.2.

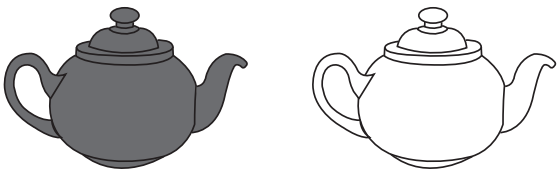

Fig. 3.2

The teapots each contain the same amount of hot water.

State and explain which teapot will cool down more quickly.

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..... [3]

5054/02/O/N/06/Q3

22 Fig. 4.1 shows equipment placed on top of a house that uses solar energy to produce hot water.

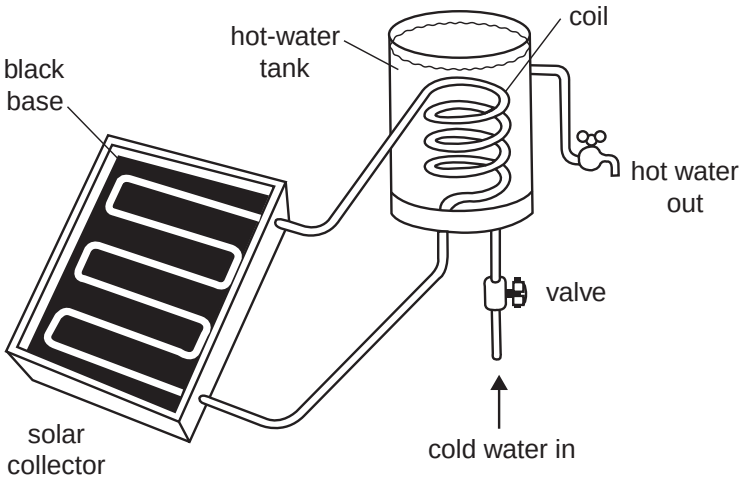

Fig. 4.1

(a) Explain why the solar collector has a black base.

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..... [2]

(b) State and explain why the hot water in the solar collector travels to the hot-water tank.

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..... [2]

(c) Fig. 4.1 does not show any insulation.

(i) Explain why it is important to insulate the hot-water tank.

.....

..... [1]

(ii) Explain how the hot-water tank is insulated.

.....

..... [1]

5054/02/O/N/07/Q4

23 Fig. 5.1 shows the arrangement of atoms in a solid block.

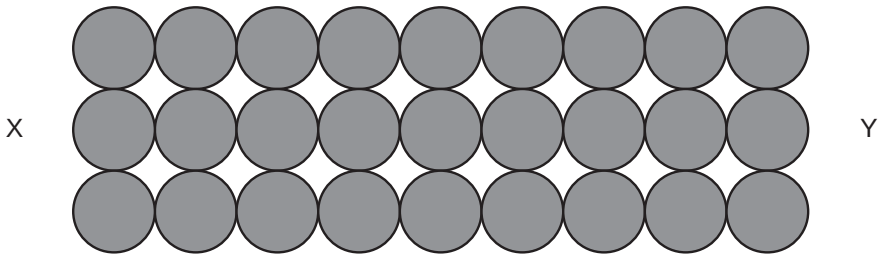

Fig. 5.1

(a) End X of the block is heated. Energy is conducted to end Y, which becomes warm.

(i) Explain how heat is conducted from X to Y by the atoms.

.....

.....

..... [2]

(ii) Explain why the solid block expands when it is heated.

.....

.....

..... [1]

5054/02/O/N/07/Q5

24 Fig. 9.1 shows an electric boiler in a school kitchen.

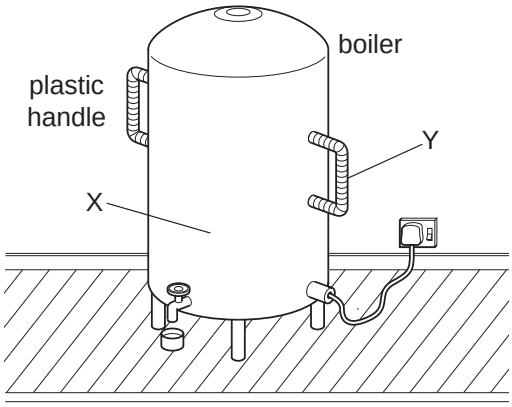

Fig. 9.1

(b) **(i)** The immersion heater is placed in the water at the bottom of the boiler. Explain in detail how this ensures that the thermal energy (heat) is transferred throughout the water. [4]

(ii) The boiler is made of steel and has two large plastic handles. When the water is boiling, the steel surface at X is hot while the plastic handle at Y is cool. Explain why. [2]

5054/02/O/N/09/Q9

25 **(b)** Fig. 3.2 shows the firefighter.

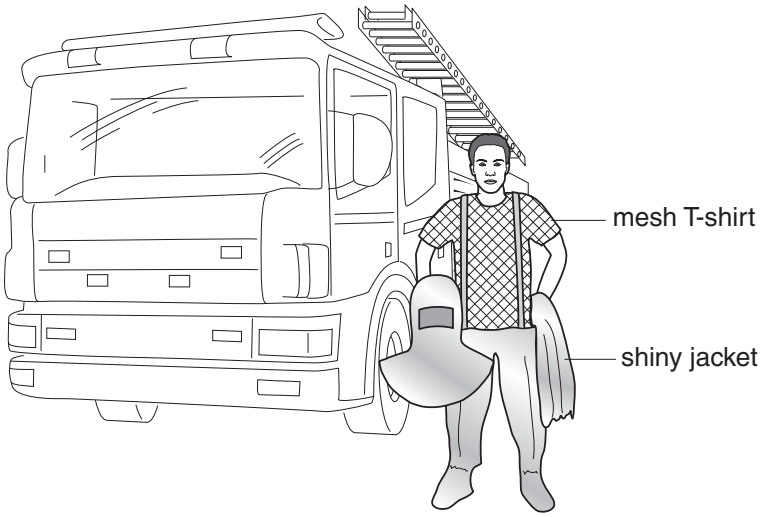

Fig. 3.2

The jacket of his protection suit has a shiny, silver-coloured outer surface. Underneath it he wears a loosely-woven mesh T-shirt (string vest).

Explain how wearing the shiny jacket and the mesh T-shirt helps to keep the firefighter cool when he is close to a source of intense heat.

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.....

.....[4]

5054/22/O/N/10/Q3

26 **(c)** Fig. 10.2 is a diagram of the heater standing on the floor of the room and placed next to one of the walls.

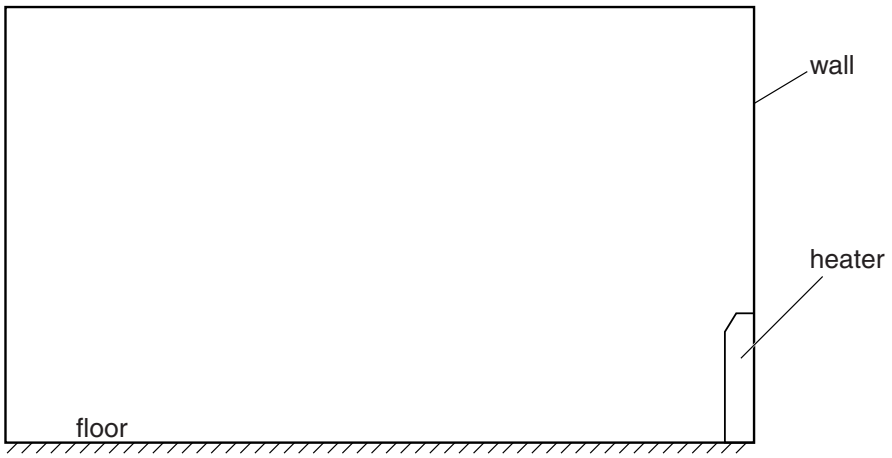

Fig. 10.2

Describe, and explain in detail, how the thermal energy is transferred throughout the room. You may draw on Fig. 10.2.

.....

.....

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.....

.....

..... [5]

(d) State one method of thermal insulation that is used to keep a room warm, and explain why it is effective.

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..... [3]

5054/21/O/N/12/Q10

27 **(a)** No thermal energy (heat) is transferred from the surface of the Sun to the Earth by either conduction or convection.

Explain why this is so.

.....

.....

..... [2]

(b) In a certain country, the climate is very sunny and hot during the day and extremely cold during the night.

Explain how painting the houses white helps to maintain a comfortable temperature both during the day and during the night.

during the day: .....

.....

.....

during the night: .....

.....

.....

[3]

5054/22/O/N/12/Q5

28 Fig. 4.1 shows food being cooked in an electric grill.

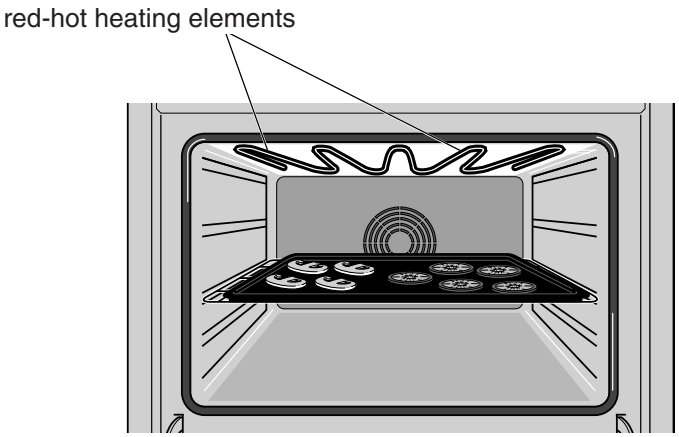

Fig. 4.1

There are red-hot heating elements above the food and thermal energy (heat) is transmitted to the food by radiation.

(a) Explain what is meant, in this case, by *radiation*.

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.....

.....[2]

(b) Explain why very little thermal energy is transmitted to the food by

(i) conduction,

.....

.....[1]

(ii) convection.

.....

.....[1]

5054/21/O/N/13/Q4

29 The casing of an electric kettle is made of white plastic. Fig. 10.1 shows the heating element positioned in the base of the kettle.

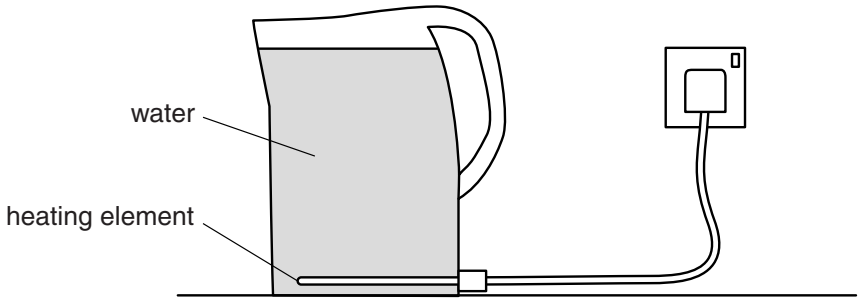

Fig. 10.1

(a) **(i)** The heating element supplies thermal energy to the water at the bottom of the kettle.

Describe and explain how the thermal energy is transferred throughout the water.

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.....[3]

(ii) Explain why a kettle with its heating element in the water at the top of the kettle does not heat the water uniformly.

.....

.....[1]

(c) Explain one advantage of

(i) using plastic for the casing of a kettle,

.....

.....[1]

(ii) choosing white as the colour for the outside of the casing.

.....

.....[1]

5054/21/O/N/14/Q10

30 A copper saucepan with a wooden handle contains cold water. The saucepan is placed on a red-hot heating element that is a part of an electric cooker.

Fig. 4.1 shows the saucepan on the heating element.

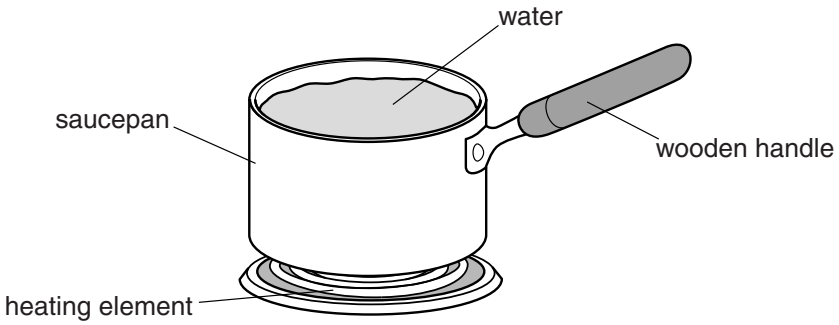

Fig. 4.1

(a) Explain why wood is a suitable material for the handle of the saucepan.

..... [1]

(b) **(i)** Describe and explain, in terms of free electrons, how thermal energy is transferred through the copper base of the saucepan.

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..... [3]

(ii) Describe and explain how thermal energy is transferred upwards through the water.

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..... [3]

5054/22/O/N/15/Q4

15

31 (b) (ii) The pan is placed on an electric hotplate, as shown in Fig. 10.1.

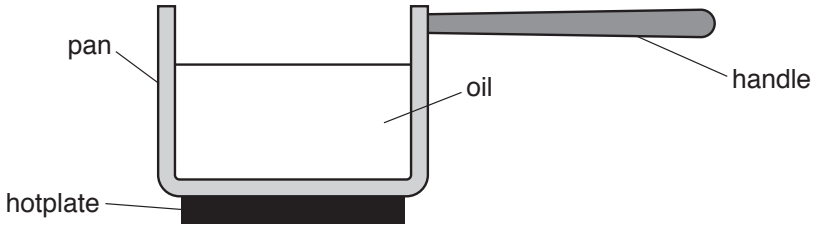

Fig. 10.1

1. Explain, in terms of molecules or free electrons, how thermal energy is conducted through the metal base of the pan.

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.....

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.....[3]

2. Explain how thermal energy spreads to all the oil in the pan.

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.....[3]

3. Suggest and explain a suitable material for the handle of the pan.

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.....[1]

5054/21/O/N/16/Q10

32 **(c)** Fig. 10.1 shows the heater at the bottom of the water in the boiler.

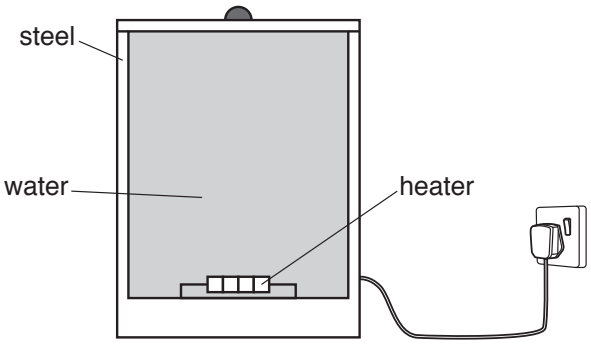

Fig. 10.1

(i) Explain how thermal energy is transferred from the heater throughout the water.

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.....[3]

(ii) The part of the boiler that holds the water is made from steel.

Describe, in terms of particles, how thermal energy passes through the steel.

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.....[3]

(iii) State and explain, in terms of particles, what happens to the density of the steel as its temperature increases.

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.....[2]

5054/22/O/N/17/Q10

33 Fig. 3.1 shows a cylindrical copper kettle that contains cold water.

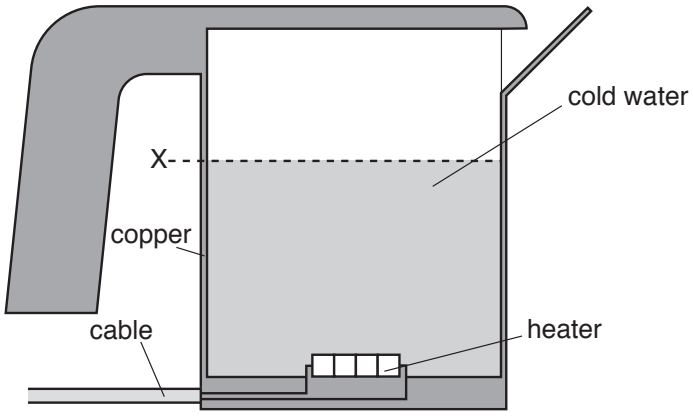

Fig. 3.1

The kettle is used to heat water and there is an electric heater at the base.

(a) State and explain the advantage of heating the water from below.

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..... [2]

(b) As the water is heated, it expands.

(i) Explain, in terms of molecules, why water expands when it is heated.

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.....

.....

..... [2]

(ii) Copper also expands when heated.

State what happens to level X of the water in the kettle. Explain your answer in terms of the expansion of the copper and the water.

.....

.....

..... [1]

5054/22/O/N/18/Q3

34 A house has several solar panels on the roof.

These panels use energy from the Sun both to generate electricity and to raise the temperature of water that passes through tubes inside the panels.

(a) The panels on the roof of the house have a black surface.

(i) State how energy from the Sun travels through space before it reaches the Earth.

.....

..... [1]

(ii) Explain the advantage of using panels that have a black surface.

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.....

.....

..... [2]

5054/22/O/N/18/Q4

35 Fig. 9.1 shows the structure of a water cooler that is used to supply cold water to the workers in a hot office.

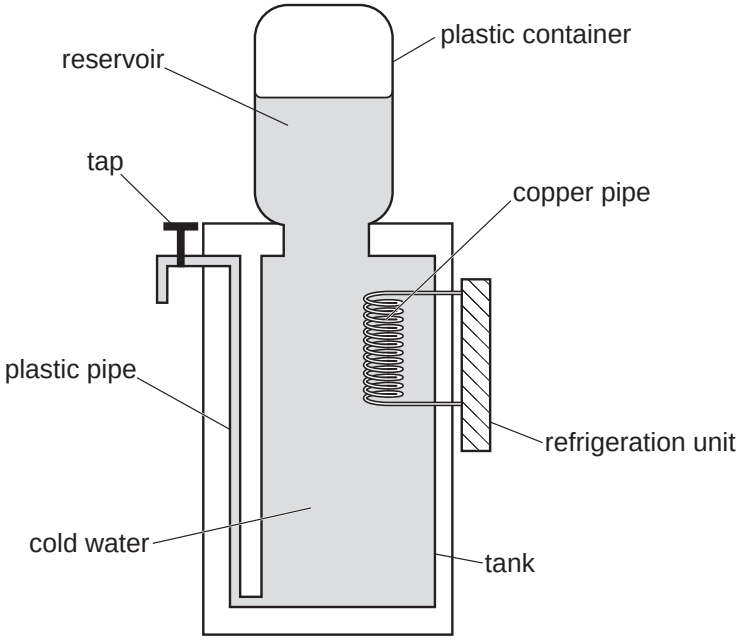

Fig 9.1

(a) The reservoir of water in the plastic container is at room temperature. It does not mix with the cold water in the tank below.

Explain why.

.....

.....

..... [2]

(b) When the tap is opened, water at room temperature from the reservoir flows down into the tank. Cold water from the tank flows through the plastic pipe and out of the tap.

Cold liquid from the refrigeration unit is pumped through the copper pipe and thermal energy passes through the copper to this liquid.

(i) Suggest why this pipe is made from copper.

.....

..... [1]

(ii) Explain, in terms of free electrons, how thermal energy is transferred through the copper.

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.....

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..... [3]

(iii) As the water near the copper pipe cools, it begins to mix with the rest of the water in the tank.

Explain how this happens.

.....

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..... [3]

5054/21/O/N/19/Q9

36 Solar panels are used to heat water.

(a) The energy absorbed by solar panels comes from the Sun.

(i) Describe how this energy is produced inside the Sun.

.....

.....

..... [2]

(ii) State how this energy is transferred to Earth.

..... [1]

(b) Explain why solar panels are usually black.

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..... [2]

5054/22/O/N/19/Q3

37 Fig. 3.1 shows a hot water tank that contains two electric heaters X and Y.

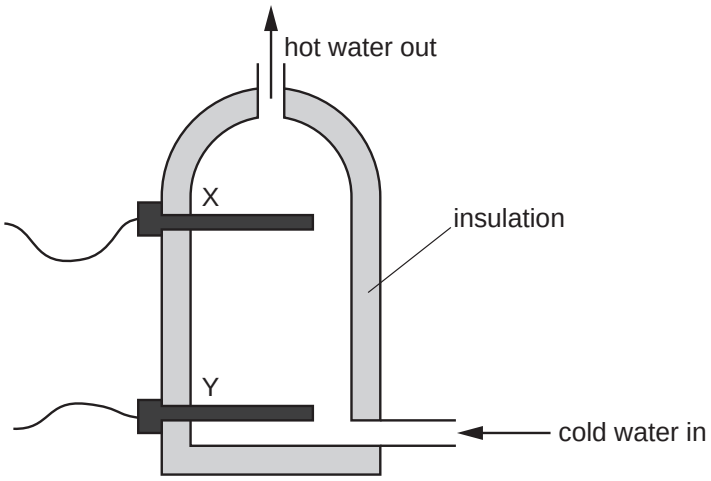

Fig. 3.1

Heater X is used during the daytime but heater Y is only used at night when electricity is cheaper.

(a) The tank is full of cold water and X is switched on.

The temperature of **all** the water above X increases very quickly but the temperature of the water below X increases much more slowly.

(i) Explain the process that causes the water above X to increase in temperature.

.....

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.....

..... [3]

(ii) Heater Y remains switched off. Explain why the temperature of the water below heater X increases much more slowly than the temperature of the water above heater X.

.....

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.....

..... [2]

(b) The hot water tank is covered in a thick layer of insulating material. The material is a plastic that contains a large number of small pockets of trapped air.

Explain why this material is a good insulator.

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..... [2]

5054/22/O/N/20/Q3

38 A type of nuclear reaction takes place at the centre of the Sun. The reaction releases thermal energy.

(a) State the name of the type of nuclear reaction that takes place at the centre of the Sun.

..... [1]

(b) Thermal energy is emitted from the surface of the Sun into space. The energy is transferred through the vacuum of space by thermal radiation.

(i) Describe the radiation that is emitted from the surface of the Sun.

.....

.....

..... [2]

(ii) State the speed of this radiation in a vacuum.

speed = ... [1]

(iii) The Earth is 1.5×10^{11} m from the surface of the Sun.

Calculate the time taken for this radiation to travel to Earth.

time = ... [2]

(c) Explain one advantage of wearing white clothes on sunny days.

.....

.....

..... [2]

5054/21/O/N/21/Q3