2. Thermal physics

2.3 Transfer of thermal energy

Paper 1 and 2

Question Paper

Paper 1

Questions are applicable for both core and extended candidates

1 A beaker of water is heated and thermal energy travels through the water by convection.

What happens to the density of the water when it is heated and how does the water move?

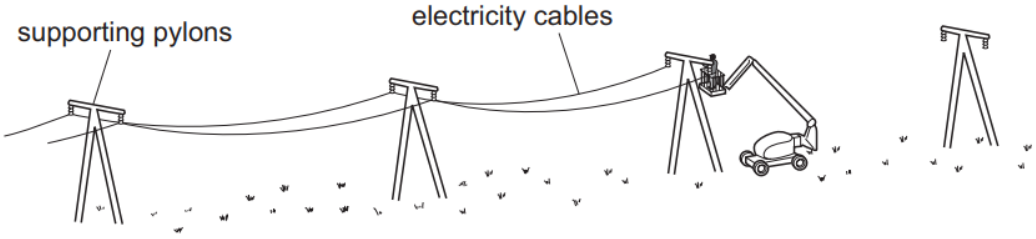
A The density decreases and the heated water moves downwards.

B The density decreases and the heated water moves upwards.

C The density increases and the heated water moves downwards.

D The density increases and the heated water moves upwards.

2 The diagram shows electricity cables being put up on a warm day. The cables are suspended between the supporting pylons, as shown.



Why are the cables **not** tightened to make them higher above the ground?

A They will contract on cold days.

B They will contract on very warm days.

C They will expand on cold days.

D They will expand on very warm days.

3 In which situation is radiation the **main** method by which energy is transferred?

A heating a pan of water using a gas camping stove

B energy reaching the Earth from the Sun

C heating the air in a room with a convection heater

D giving gravitational potential energy to a glider when it is lifted by thermal currents

4 A student stirs a hot liquid in a pan with a spoon.

Which row explains which material the spoon should be made from so that the student does **not** burn their hand?

	material of spoon	explanation
A	metal	it is a good conductor
B	metal	it is a good insulator
C	wood	it is a good conductor
D	wood	it is a good insulator

5 Thermal radiation is emitted from all objects.

Which mediums can thermal radiation travel through?

	glass	water	air	vacuum
A	✓	✓	✓	✓
B	✓	✓	✓	✗
C	✗	✓	✓	✓
D	✗	✗	✗	✓

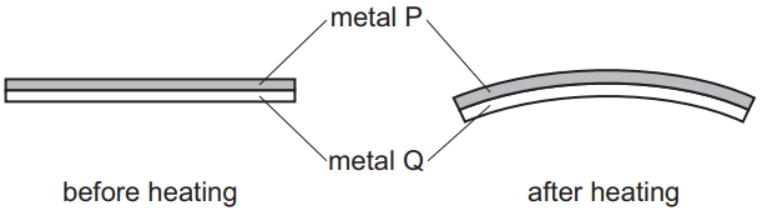
key

✓ = can travel through this medium

✗ = cannot travel through this medium

6 A bimetallic strip is used to control the temperature of an electrical appliance. It is made of two different metals fixed together.

The diagram shows the shape of the bimetallic strip before and after heating.



Which statement is correct?

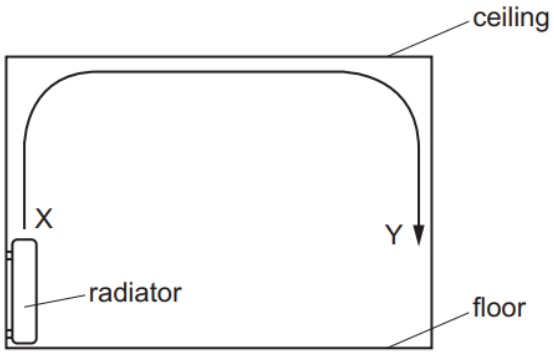
A Metal P contracts more than metal Q on heating.

B Metal Q contracts more than metal P on heating.

C Metal P expands more than metal Q on heating.

D Metal Q expands more than metal P on heating.

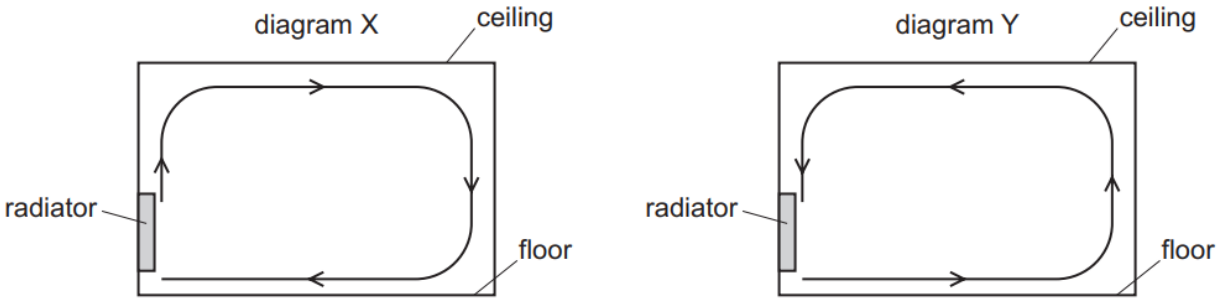
7 The diagram shows the view of a room heated by a radiator. The arrowed line from X to Y is the path of the convection current in the air.



Which row about the air temperature and the air density at X and at Y is correct?

	air temperature	air density
A	higher at X	higher at X
B	higher at X	higher at Y
C	higher at Y	higher at Y
D	higher at Y	higher at X

8 A room is heated by a radiator. The diagrams X and Y show two possible circulations of hot air, which heat the room.



Which diagram and reason explain the heating of the room by convection?

	diagram	reason
A	X	air density decreases when air is heated
B	X	air density increases when air is heated
C	Y	air density decreases when air is heated
D	Y	air density increases when air is heated

9 Which surface is the worst absorber of infrared radiation?

A dull black

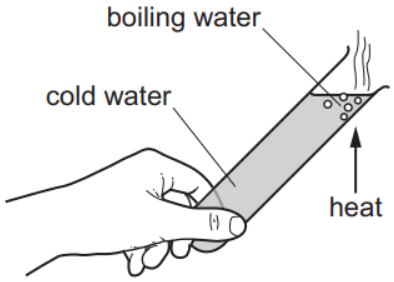
B dull white

C shiny black

D shiny white

10 A teacher puts some cold water in a test-tube.

She holds the bottom of the test-tube while heating the top.



The water at the top boils but she continues to hold the test-tube as the bottom remains cold.

Which conclusion about water is made from this experiment?

A Water is a bad conductor.

B Water is a bad convector.

C Water is a good conductor.

D Water is a good convector.

11 Four thermometers, with their bulbs painted different colours, are placed at equal distances from a radiant heater.

Which thermometer shows the slowest temperature rise when the heater is first switched on?

A dull black

B dull white

C shiny black

D shiny white

12 Which method of transfer of thermal energy is caused by changes in density?

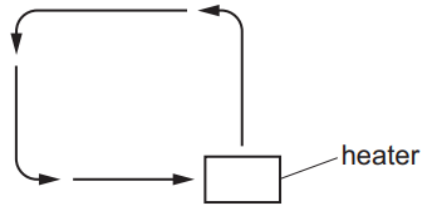
A conduction

B convection

C evaporation

D radiation

13 Particles can move, transferring thermal energy, as shown.



In which states of matter does this movement occur?

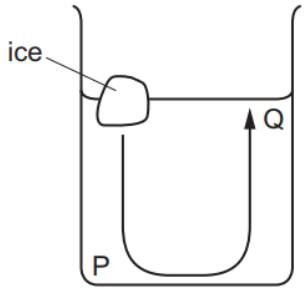
A gas and liquid only

B gas and solid only

C gas, liquid and solid

D liquid and solid only

14 The diagram shows a convection current caused by a piece of ice placed in a beaker of water at room temperature.



Which row correctly compares the temperatures and densities at water points P and Q?

	temperature at P	density at P
A	higher than at Q	higher than at Q
B	higher than at Q	lower than at Q
C	lower than at Q	higher than at Q
D	lower than at Q	lower than at Q

15 The outside of one of two identical shiny metal containers is painted dull black. The containers are filled with equal masses of hot water at the same temperature.

Why does the dull black container cool more quickly?

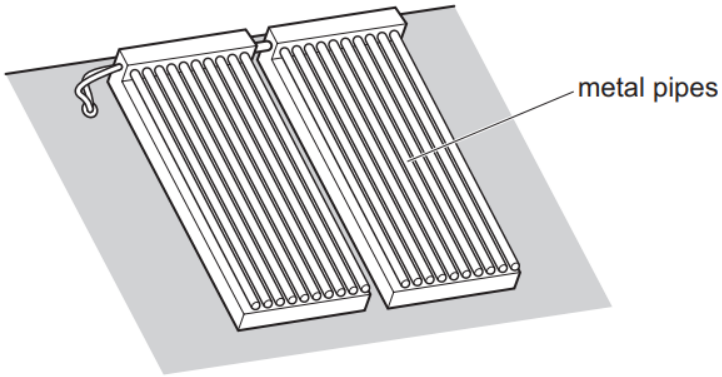
A Black surfaces are better conductors than shiny surfaces.

B Black surfaces are better emitters of radiation than shiny surfaces.

C Black surfaces are better reflectors of radiation than shiny surfaces.

D Black surfaces are worse absorbers of radiation than shiny surfaces.

16 The diagram shows solar water panels on the roof of a house. The panels absorb energy from the Sun to heat up the water in the metal pipes.



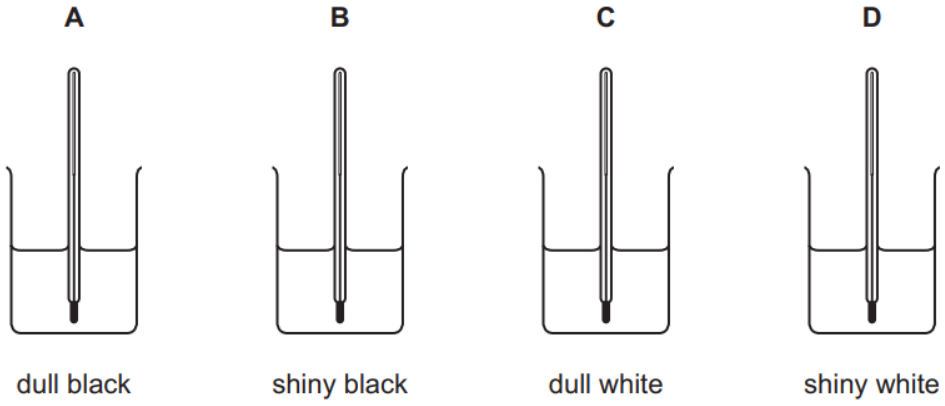
Which row describes how energy is transferred from the Sun and through the metal of the pipes?

	from the Sun	through the metal of the pipes
A	conduction	conduction
B	conduction	convection
C	radiation	conduction
D	radiation	convection

17 Four beakers containing equal volumes of water at 10 °C are placed outside in full sunshine on a hot day.

The four beakers are identical except for their surface colour and texture.

Which beaker will heat up the quickest?



18 The diagram shows a pan used for cooking food.

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

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

19 In which substances is convection a method of thermal energy transfer?

A air and water only

B air only

C air, water and wood

D water only

20 In which situation is radiation the main method by which energy is transferred?

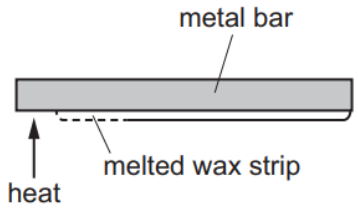
A heating a pan of water using a gas camping stove

B energy reaching the Earth from the Sun

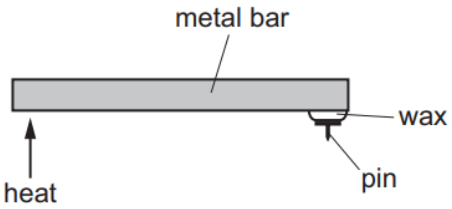
C heating the air in a room with a radiator

D giving gravitational potential energy to a glider when it is lifted by thermal currents

21 Two students carry out different experiments to compare the abilities of different metals to conduct thermal energy.



experiment 1



experiment 2

In experiment 1, the bar is heated for one minute and the length of wax strip that melts is measured.

In experiment 2, the bar is heated and the time taken for the pin to drop off is measured.

What happens to each of these measurements when a better conductor of thermal energy is tested?

	length of melted wax strip	time taken for the pin to drop
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

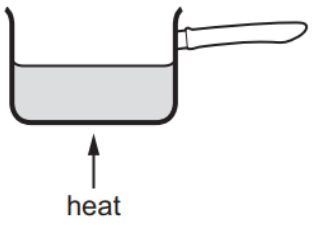
22 The table gives some examples of convection and an explanation of why the convection occurs.

Which row is correct?

	example	explanation
A	air conditioner unit	The unit is placed in a high position to circulate the cold air rising from the floor level and so keeping the room cold.
B	convection oven	The air in the oven becomes more dense when heated so it falls to the bottom heating the food faster.
C	hot-air balloon	Air inside the balloon becomes less dense which causes the balloon to rise.
D	land and sea breezes	A breeze forms due to the warm air above the land moving down towards the sea.

23 The diagram shows a pan of water being heated.

After a short time, all the water in the pan begins to boil.



What is the main process by which thermal energy is transferred through the water?

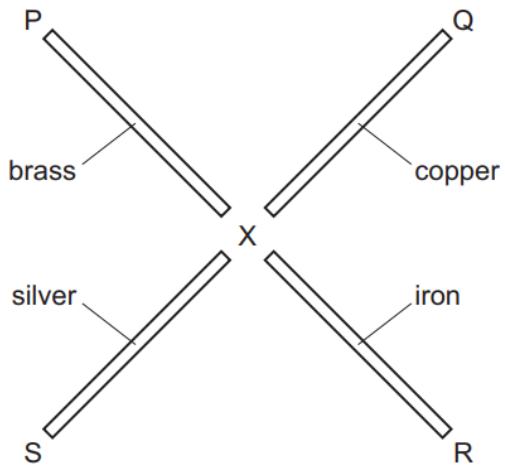
A conduction

B convection

C evaporation

D radiation

24 The diagram shows four rods. Each rod is made of a different metal.



Wax is used to attach small metal balls at the rod ends P, Q, R and S.

Each rod is the same size. They are heated uniformly by a Bunsen burner at point X.

As the rods warm up, the wax melts and the balls fall off.

Why does the ball on the silver rod fall first?

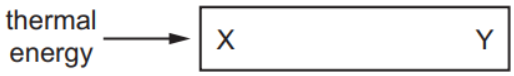
A Silver is the best conductor of heat.

B Silver is the worst conductor of heat.

C Silver is the best radiator of heat.

D Silver is the worst radiator of heat.

25 Thermal energy is supplied at the same rate to four bars made from different materials.



After several minutes, there is a temperature difference between X and Y for each bar.

Which statement identifies the bar with the greatest temperature difference between points X and Y, and gives the correct reason?

A copper because it is a good conductor of thermal energy

B lead because it is the densest metal

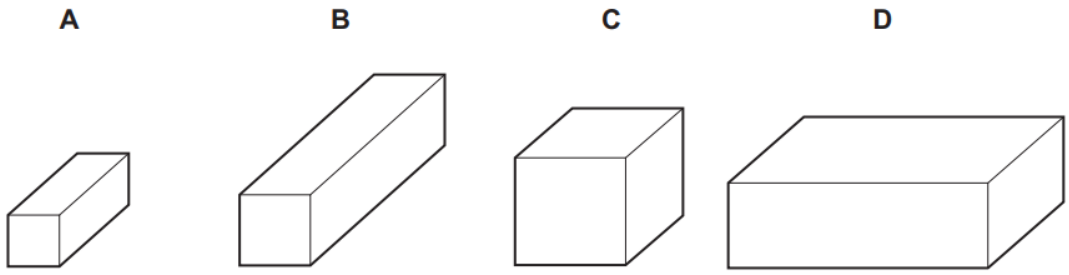
C plastic because it is a poor conductor of thermal energy

D wood because it is a good conductor of thermal energy

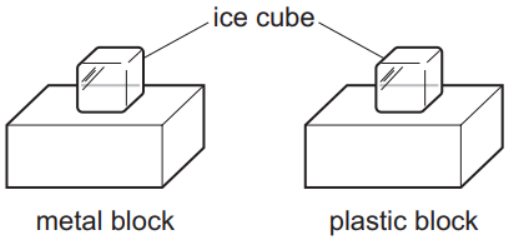
26 The diagrams show four blocks of steel. The blocks are all drawn to the same scale.

The same quantity of thermal energy is given to each block.

Which block shows the greatest rise in temperature?



27 One ice cube is placed on a metal block. An identical ice cube is placed on a plastic block. The blocks are left next to each other on a table in a laboratory.



Which ice cube melts first and why?

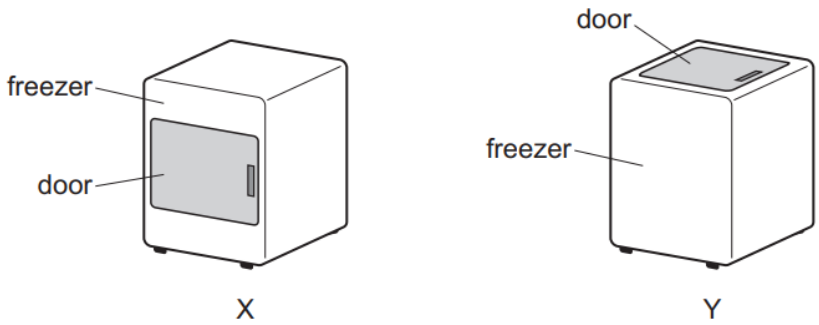
A The ice cube on the plastic block melts first because plastic is a good insulator of thermal energy.

B The ice cube on the plastic block melts first because plastic is a good conductor of thermal energy.

C The ice cube on the metal block melts first because metal is a good conductor of thermal energy.

D The ice cube on the metal block melts first because metal is a good insulator of thermal energy.

28 Two freezers X and Y are identical except that one has a door opening at the front and the other has a door opening at the top.



Both doors are the same size and are opened for the same amount of time.

Which freezer gains the least amount of thermal energy in this time and why?

	freezer gaining the least thermal energy	reason
A	X	cold air falls
B	X	warm air falls
C	Y	cold air falls
D	Y	warm air falls

29 A metal block is left overnight in a cool, shady room. In the morning, the metal block is moved into warm surroundings.

Which statement about the metal block is correct in the morning?

A The internal energy of the metal block increases.

B The temperature of the metal block decreases.

C Convection transfers energy throughout the metal block.

D The metal contracts slightly.

30 Two similar liquid-in-glass thermometers P and Q are placed in direct sunlight.

The bulb of thermometer P is painted white. The bulb of thermometer Q is painted black.

How and why would the thermometer readings differ?

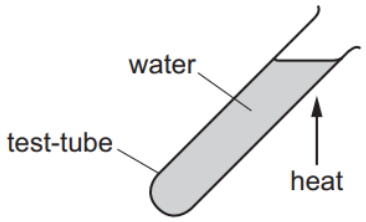
A P would read higher than Q because black is a good absorber of radiation.

B P would read higher than Q because black is a poor absorber of radiation.

C P would read lower than Q because black is a good absorber of radiation.

D P would read lower than Q because black is a poor absorber of radiation.

31 A glass test-tube containing water is heated at the top. The water at the top boils, but the water at the bottom remains cold.



Which row explains why the water at the bottom of the test-tube remains cold?

	glass	water
A	good thermal conductor	good thermal conductor
B	good thermal conductor	poor thermal conductor
C	poor thermal conductor	good thermal conductor
D	poor thermal conductor	poor thermal conductor

32 In countries where it is usually hot, houses are often painted white.

What is the reason for this?

A White surfaces are good reflectors of radiant energy.

B White surfaces are good transmitters of radiant energy.

C White surfaces are good absorbers of radiant energy.

D White surfaces are good emitters of radiant energy.

33 Which method of thermal transfer occurs when the density of some of a liquid decreases and the liquid moves upwards?

A conduction

B convection

C evaporation

D radiation

34 The diagram shows a tent made from a new material.

What type of material should the tent be made of to reflect the radiant energy from the Sun?

	material texture	material surface colour
A	dull	black
B	dull	white
C	shiny	black
D	shiny	white

35 In which does thermal conduction **not** occur?

A a gas

B a liquid

C a solid

D a vacuum

36 The metal surface of a kettle is hot.

What happens to the cool air outside the kettle when it comes into contact with the hot kettle?

A The density of the air decreases and the air falls.

B The density of the air decreases and the air rises.

C The density of the air increases and the air falls.

D The density of the air increases and the air rises.

37 Vacuum flasks usually have silvered walls that help to keep the contents of the flask hot.

Why are the walls silvered?

A to absorb thermal energy from the air around the flask

B to increase the rate of convection inside the flask

C to reduce energy loss to the surroundings by conduction

D to reflect thermal radiation back into the flask

38 A liquid is heated and it expands.

How does this lead to the formation of a convection current?

A The density of the heated liquid decreases.

B The density of the heated liquid increases.

C The mass of the heated liquid molecules decreases.

D The mass of the heated liquid molecules increases.

39 Which statement about convection is **not** correct?

A It enables water in a pan on a cooker to get evenly heated.

B It happens in liquids and gases.

C It means that heat rises.

D It occurs because the density of a fluid decreases when it is heated.

40 On a cold day, a metal front-door knob X and a similar plastic knob Y are at the same temperature.

Why does X feel cooler to the touch than Y?

A X convects thermal energy better than Y.

B X is a better thermal conductor than Y.

C X is a better insulator than Y.

D X is a better radiator of thermal energy than Y.

Paper 2

Questions are applicable for both core and extended candidates

41 Which statement about the transfer of thermal energy is correct?

A All metals conduct thermal energy equally well.

B Convection can only occur in solids or liquids.

C Convection occurs in liquids because hot liquid is more dense than cold liquid.

D The radiation that transfers thermal energy is a type of electromagnetic radiation.

42 A solar water heater is designed to absorb energy from sunlight.

Which surface texture and colour would be best for the solar water heater?

A dull black

B shiny black

C dull white

D shiny white

43 A teacher shows his class a polystyrene cup. The polystyrene is a thick plastic with lots of tiny air bubbles in it.

He asks the class why the cup is so good at keeping a hot drink warm. Three suggestions are made.

1 It contains air which is a poor thermal conductor.

2 The air is trapped in tiny bubbles so very little convection is possible.

3 The plastic is a poor thermal conductor.

Which suggestions are correct?

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

44 Four cups **A**, **B**, **C** and **D** contain hot coffee.

Which cup keeps the coffee warm the longest?

	the outside surface of the cup	the top of the cup
A	black	covered with a lid
B	black	no lid
C	white	covered with a lid
D	white	no lid

45 One end of a copper bar is heated to a high temperature. **(extended only)**

Which mechanism is responsible for the transfer of thermal energy to the other end of the copper bar?

A the lattice vibrations of copper ions only

B the lattice vibrations of copper ions and the movement of high energy electrons along the bar

C the movement of high energy copper ions along the bar

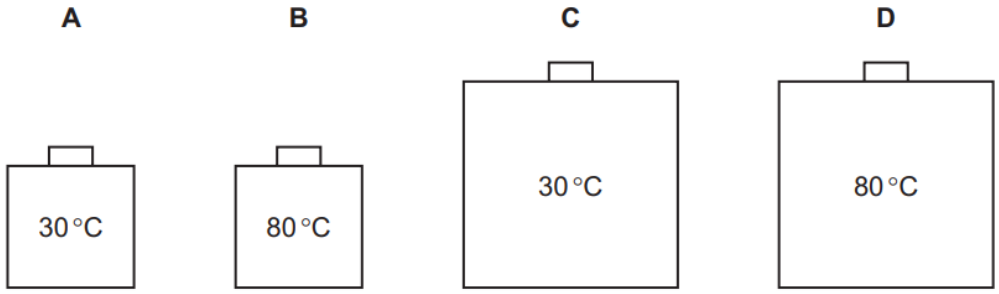
D the movement of high energy electrons along the bar only

46 Four cubic copper containers are filled with water. The surfaces of all the containers are painted black.

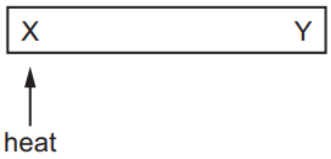
Two of the containers have sides of length 20 cm and the other two containers have sides of length 40 cm.

Two of the containers contain water at 80 °C and the other two contain water at 30 °C.

Which container radiates energy at the lowest rate? **(extended only)**



47 A metal rod is heated at end X. **(extended only)**



Why does end Y of the metal rod become hot?

A Energy is transferred from end X of the rod to end Y by vibration of positive ions and by movement of electrons.

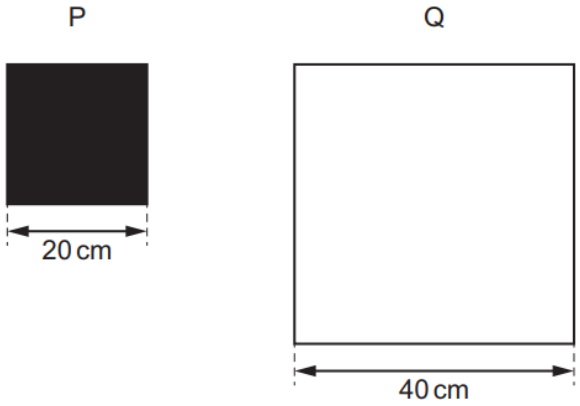
B Energy is transferred from end X of the rod to end Y by movement of positive ions only.

C Energy is transferred from end X of the rod to end Y by vibration of positive ions only.

D Energy is transferred from end X of the rod to end Y by movement of electrons only.

48 Two square sheets of metal, P and Q, are heated to the same temperature. The metal sheets are shown.

(extended only)



Sheet Q is emitting more radiation than sheet P.

Which statement explains this?

A Dull black surfaces are better conductors of radiation.

B Dull black surfaces are better emitters of radiation.

C The surface area of Q is larger than that of P.

D White surfaces are better absorbers of radiation.

49 A student sets up four cans. Each can contains the same mass of water at 90 °C.

The cans are identical except for the outside surfaces.

Which can will cool down the fastest?

A dull, black surface

B dull, white surface

C shiny, black surface

D shiny, white surface

50 Thermal energy is transferred by conduction in a metal bar. **(extended only)**

Which statement is **not** correct?

A Fast vibrating ions leave the surface.

B Free moving electrons carry thermal energy through the bar.

C Ions vibrate and strike neighbouring ions to make them vibrate.

D Ions vibrate but do not change position.

51 Four solid spheres made of the same metal are heated to the same temperature.

Which sphere initially loses thermal energy by radiation at the greatest rate? **(extended only)**

A diameter of 10 cm with a dull surface

B diameter of 10 cm with a shiny surface

C diameter of 5 cm with a dull surface

D diameter of 5 cm with a shiny surface

52 Why are metals better thermal conductors than other solids? **(extended only)**

A Metals contain free electrons which help transfer the energy.

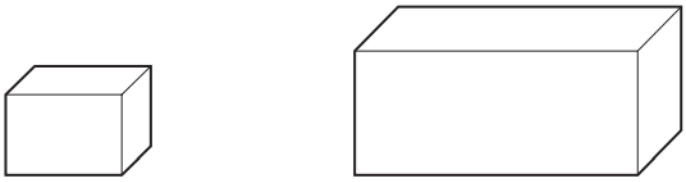
B Molecules in metals are in fixed positions.

C Molecules in metals can move freely.

D Molecules in metals vibrate faster than those in other solids.

53 Two copper containers P and Q are filled with hot water.

The diagrams are both drawn to the same scale.



P Q

Container P emits more infrared radiation from its surfaces than container Q.

What is a possible reason for this?

A The surfaces of P are painted white and the surfaces of Q are painted black.

B The surfaces of P are shiny and the surfaces of Q are dull.

C The surfaces of P have a smaller area than the surfaces of Q.

D The water in P is hotter than the water in Q.

54 One end of a rod of copper is placed in hot water. Thermal energy travels along the rod to make the other end warmer.

(extended only)

What is the behaviour of the copper at an atomic level that accounts for most of the transfer of thermal energy from one end to the other?

A Atoms at the hot end gain kinetic energy and move towards the other end.

B Atoms at the hot end expand, colliding with other atoms and transferring energy.

C Free electrons at the hot end gain energy and move towards the other end, colliding with atoms along the rod.

D Free electrons at the hot end gain energy from the hot water and move directly to the other end.

55 A surface is made so that it is a good source of infrared radiation.

Which surface is **not** suitable?

A a surface that is painted matt black

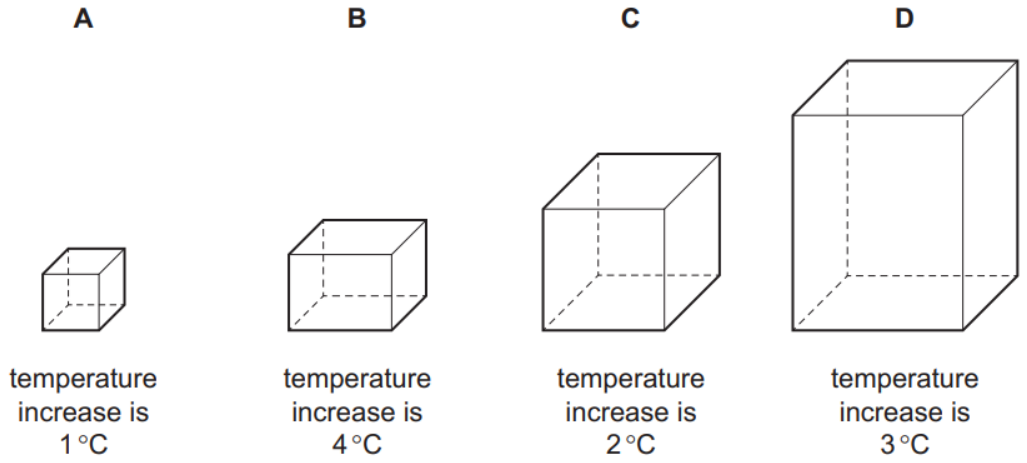
B a surface that is painted white

C a surface that is heated to a high temperature

D a surface that has a large surface area

56 The same quantity of thermal energy is supplied to each of four blocks. Each block is made from a different material.

Which block has the greatest thermal capacity? **(extended only)**



57 Some hot water is sealed inside a metal can. The can is in a vacuum in outer space. The hot water slowly cools down.

How does the thermal energy escape into space?

A by conduction then convection

B by conduction then radiation

C by evaporation then convection

D by evaporation then radiation

58 The handle of a metal saucepan is made of plastic. As the saucepan heats up, the handle gets warmer.

Which statement explains this? **(extended only)**

A Molecules of the plastic radiate their energy to other molecules.

B Molecules of the plastic vibrate more and pass on their energy to nearby molecules.

C The free electrons in the plastic transfer the thermal energy along the handle.

D The heated molecules very slowly move along the plastic handle.