Name: **Index No:**

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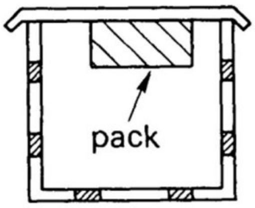
Assignment 09: Thermal processes

1. A pack, which contains a frozen liquid, is placed in a holder under the lid of a box as shown in the diagram. The box is then used to keep the food cold.



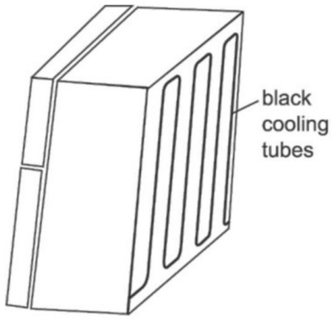
(a) Suggest why the frozen pack is placed at the top of the box rather than at the bottom. [3]

(b) Why does the food keep cold longer if the walls of the box are made

(i) of rigid plastic rather than of metal, [2]

(ii) double-layered? [2]

2. The diagram shows the back of a refrigerator. There are some cooling tubes painted black.

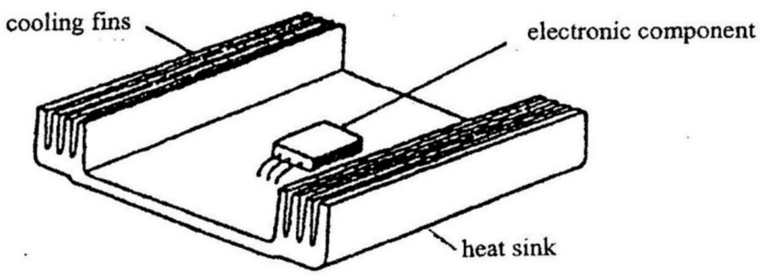


(a) Explain why the cooling tubes are painted black. [1]

(b) Explain why the cooling tubes are coiled. [1]

(c) Why is there a need to keep some space between the back of the refrigerator and the wall? [2]

3. Electronic components can be damaged by overheating. To overcome this problem, the component is mounted on a 'heat sink' as shown in the diagram below. This is often in the form of a piece of aluminium of mass greater than that of the component.



The purpose of the 'heat sink' is to absorb surplus heat produced by the electric current in the component and transfer this heat to the surroundings.

(a) Suggest reasons for

(i) making the ‘heat sink’ from aluminium, [1]

(ii) having cooling fins on the ‘heat sink’. [1]

(b) What colour should the ‘heat sink’ be painted? Explain your answer clearly. [2]

(c) The contact between the heat sink and the electronic component may not be optimal due to an air gap. As such, some thermal paste is usually applied between the heat sink and the electronic component. It is found that the electronic component did not overheat when the thermal paste is applied whereas the electronic component overheated when the thermal paste is not applied. The thermal paste is not electrically conducting.

Explain how the application of the thermal paste prevents overheating. [2]

4. Fig. 4.1 shows a kind of cloth lantern in China. It consists of two parts, the outer part and the inner part. A candle is placed at the centre of the lantern and pictures are painted on the inner part and outer part of the lantern. Above the candle, some blades are connected to the inner part of the lantern (See Fig 4.2.) and the inner part rotates continuously when the candle is lit.

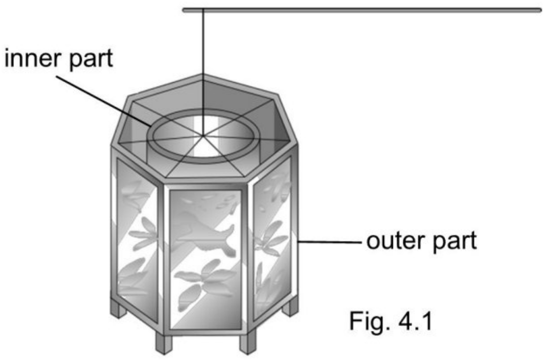


Fig. 4.1

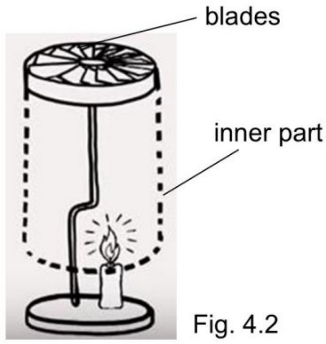


Fig. 4.2

Watch to help you visualize how it works:

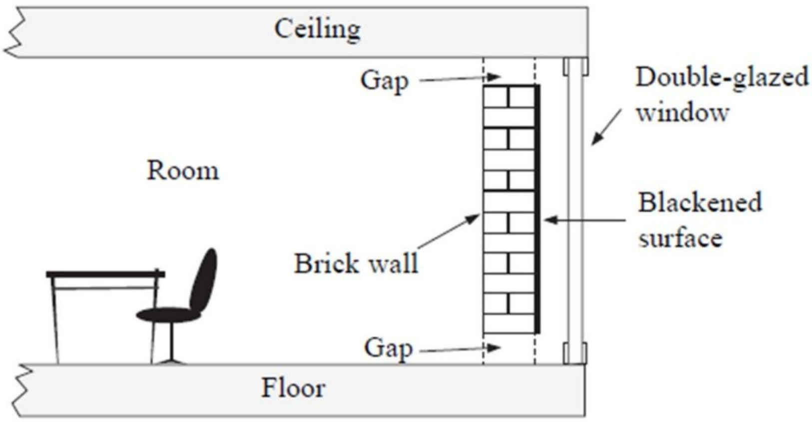
Source: https://www.youtube.com/watch?v=3RpevU9FzVM

(a) When the candle is lit, why is the inner part able to rotate? [2]

(b) Name the two main thermal processes of energy transfer in the lantern. [2]

(c) If the candle is replaced with an LED bulb which produces much less heat than a candle, explain whether there will be any change in the motion of the rotating inner part of the lantern. [2]

5. The diagram shows a method of heating a room using solar energy instead of using a heater. A brick wall with a blackened surface is placed behind a double-glazed window facing the sun. During a sunny day, the wall absorbs energy from the sun and its temperature rises.



(a) Why is the surface of the wall blackened? [1]

(b) Name one method by which energy from the blackened surface is transferred to the air next to it. [1]

(c) The double-glazed window consists of two sheets of glass which trap a layer of air between them. Explain how using a double-glazed window increases the rate at which the temperature of the room rises. [2]

(d) Give one advantage and one disadvantage of using this method to heat the room instead of using a heater. [2]

Advantage: ....

Disadvantage: ....

6. A student investigated the properties of three types of insulation. Fig. 6.1 shows the apparatus the student used. In the investigation, different insulating materials were placed in contact with the hot metal plate. Temperature probes measured the temperature on each side of the material. The temperature probes were connected to a data logger.

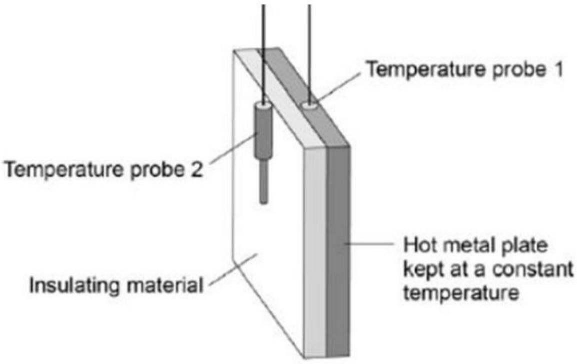


Fig. 6.1

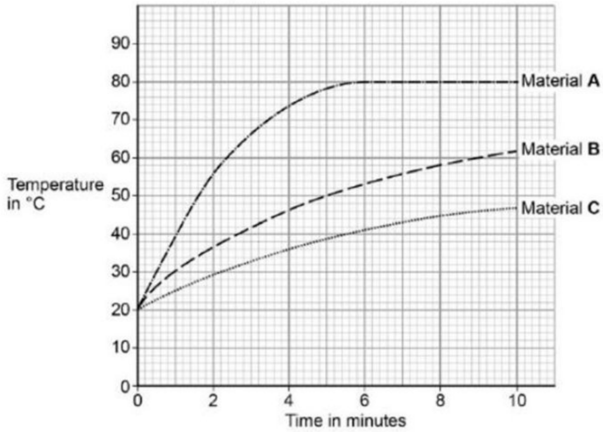


Fig. 6.2

Fig. 6.2 shows the graph of how the temperature measured by temperature probe 2 changes over 20 minutes for each of the materials.

(a) What was the temperature of the hot metal plate? [1]

....

(b) Which material (A, B or C) is the best insulator? Explain why. [2]

(c) Another student repeated the investigation but doubled the thickness for all three insulating materials. Suggest how using thicker insulation would affect the results of the second student's investigation compared with the first student's results. [1]

(d) Using the table, explain which material would be the best to use in cavity wall insulation. [2]

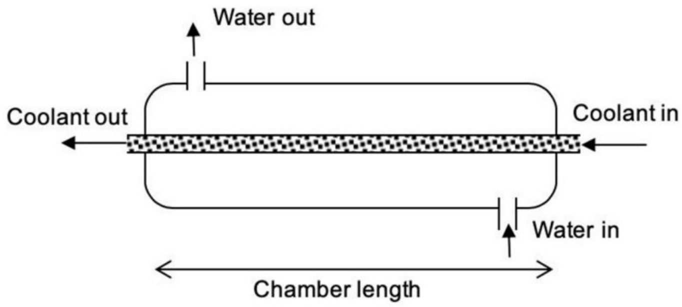
Type of insulation	Thermal conductivity in W/m °C
Felt wool	0.070
Mineral wool	0.040
Polyurethane foam	0.030
Rock wool	0.045

7. Energy is transferred from more energetic to less energetic molecules when neighbouring molecules collide. Conductive heat flow occurs in direction of the decreasing temperature since higher temperature is associated with higher average kinetic energy.

The rate of conductive heat flow, Q/t, is given as follows:

$$\frac{Q}{t} = \frac{kA(T_2 - T_1)}{d}$$

where
k: thermal conductivity of material, W m^{-1} K^{-1},
A: area, in m^2,
d: material thickness, m
T_2 - T_1: temperature difference across the material, in K or °C



Tubes in a heat exchanger

The thermal conductivity of copper is 401 $Wm^{-1}K^{-1}$.
In a heat exchanger, copper tubes that have a thickness of 0.003 m and diameter of 0.025 m are used. Every second, 126 kJ of energy is to be conducted from the water in a chamber to the coolant in the copper tubes.

(a) Determine the rate of conductive heat flow, in Watts, between the water and the coolant. [2]

(b) If the average temperature of the coolant is 8.0°C and that of the water is 10.0 °C. Calculate the required length of copper tube. [2]