Heat Conduction

U81-11 Three rods A, B and C are of the same shape and size but having different thermal conductivities. The conductivity of A is half of that of B, and the conductivity of C is double that of B. Which of the arrangements shown in Fig.U81-11 would conduct heat from S_1 (heat source of higher temperature) to S_2 (heat source of lower temperature) most effectively?

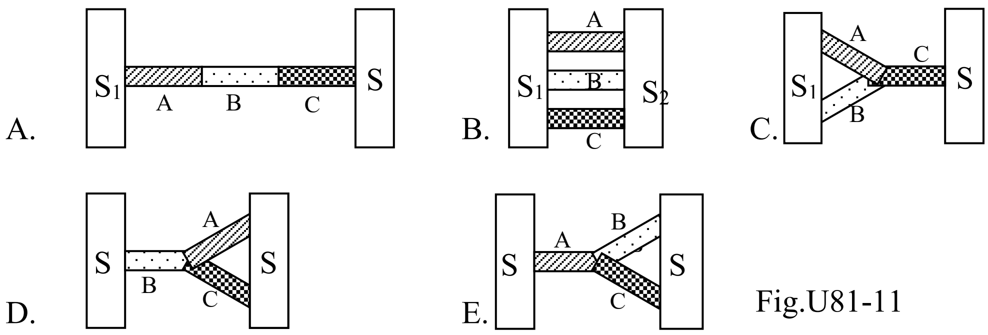

Fig.U81-11

U83-14 A lagged copper bar is supported with its ends between two metal tanks, one maintained at 100 °C and the other at 0 °C. However, there is found to be a layer of dirt between the bar and the hot tank. Which graph in Fig.2 best represents the temperature distribution along the bar?

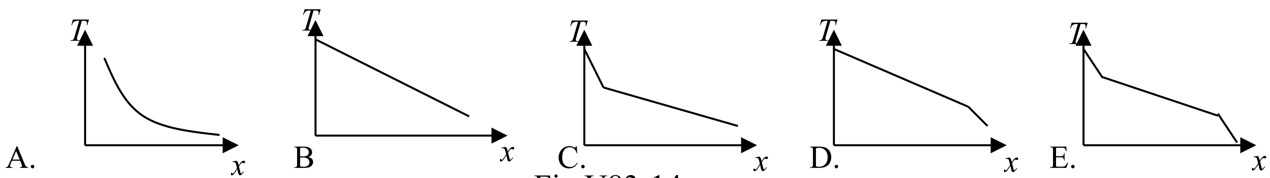

Fig.U83-14

U83-P5a What do you understand by *temperature gradient* and *thermal conductivity*? What are their respective SI units?

(b) The temperature of a room is maintained at 292 K when the outdoor temperature is 274 K (winter). The glass windows in the room have a total area of 2.0 m^2 and an average thickness of 6.0 mm. Calculate the power required to maintain this temperature difference assuming that the only heat loss is through the glass, which has thermal conductivity 0.80 W m^{-1} K^{-1}. [4800 W]

U85-15 A piece of glass which has been heated to a high temperature is left to cool. If the glass cracks, it is most probably due to the ____________ of the glass.

A. low melting point B. high melting point C. low thermal conductivity
D. high thermal conductivity E. unique specific heat capacity

U86-20 If two bodies in mutual contact do not have any transfer of heat between them, that shows they have the same _____________.

A. mass B. temperature C. amount of heat D. internal energy E. specific heat capacity

U86-1 A properly lagged cylindrical metal bar of length l_1 and diameter d_1 has one end kept at 100 °C, while the other end is in contact with ice at 0 °C. The ice is found to melt at a rate of m g per minute as a result of this contact. If the bar is replaced by another of the same material, but with length $2l_1$ and diameter $\frac{1}{2}d_1$, the amount of ice melted in 1 minute would be ________ g.

A. $\frac{1}{8}m$ B. m C. $2m$ D. $4m$ E. $8m$

U89-14 Heat energy is flowing along a well-lagged metal bar of uniform cross-sectional area A at a steady rate R. The temperature difference between two points at a distance l apart on the axis of the bar is proportional to ________.

A. RAl B. $\frac{RA}{l}$ C. $\frac{Rl}{A}$ D. $\frac{R}{Al}$ E. $\frac{1}{RAl}$

U89-P6a Define **thermal conductivity** and write down its dimensions.

(b) Two ends of a bar of uniform cross-section are maintained at fixed but different temperatures. Draw appropriate graphs to show how the temperature varies along the bar is proportional to __________.

(i) fully lagged;

(ii) unlagged.

(c) A sheet of rubber and a sheet of cardboard each of area 50 cm^2 but of thickness 3 mm and 4 mm respectively are pressed together and the outer faces of the combined unit are maintained at 0 °C and 30 °C respectively. The thermal conductivities of rubber and cardboard are 0.14 W m^{-1} K^{-1} and 0.06 W m^{-1} K^{-1} respectively. Find the quantity of heat, which will flow, across the interface of the two sheets in half an hour. [3066 J]

U91-14 Under suitable conditions, thermal energy always transfers from _________.

A. objects with larger specific heat capacity to objects with small specific heat capacity
B. objects with larger heat capacity to objects with smaller heat capacity
C. objects with larger internal energy to objects with smaller internal energy
D. objects with higher temperature to objects with lower temperature
E. objects with larger mass to objects with smaller mass

U91-P8a Define **thermal conductivity**.

(b) Explain why, in an experiment to determine the thermal conductivity of a good conductor such as a copper bar, it is necessary that the bar should be thick, of uniform cross-section and have its sides well lagged.

(c) The Earth has a crust of thermal conductivity 2 W m^{-1} K^{-1}. On the average, the temperature of the crust increases by 20 °C for each kilometer below the surface. If the radius of the Earth is 6.4×10^6 m, estimate the total rate at which heat leaves the Earth's surface by conduction through the crust. [2.06×10^{13} W]

U95-14 Heat is transmitted from body A to body B when they are in contact with each other. This is because _________.

A. the volume of body A is larger than that of body B
B. heat contained in body A is more than that in body B
C. specific heat capacity of body A is larger than that of body B
D. average kinetic energy of molecules of body A is larger than that of body B

U94-15 The ends of a well-lagged copper bar of length L are kept at steady temperatures θ_1 and θ_2 ($\theta_1 > \theta_2$). Which of the graphs in Fig.U94-15 **best** represents the relationship between the rate of flow of heat ($\frac{dQ}{dt}$) and the distance (x) from the hot end when all temperatures in the bar are steady?

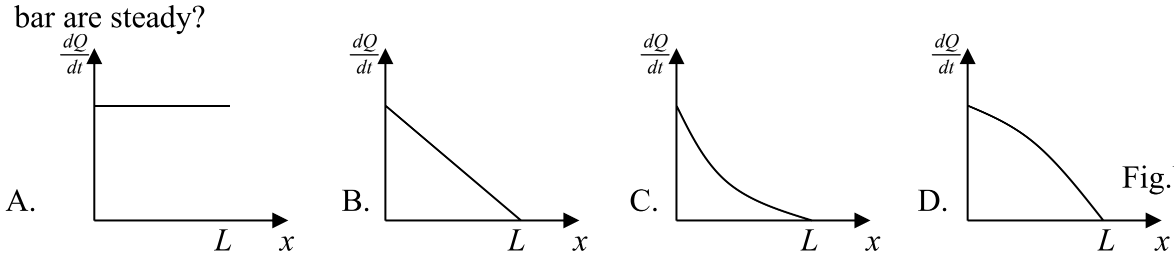

Fig.U94-15

U96-14 The thermal conductivity of a metal decreases significantly as the temperature increases. This is because at higher temperatures, ___________.

A. the distance between metallic atoms increases
B. ionic force between metallic atoms decreases
C. the rate of collision between free electrons and metallic atoms increases
D. the lattice structure slows down the vibrations of the metallic atoms

U2k07-P5a A styrofoam box used to keep drinks cold at a picnic has total wall area (including the lid) of 1.2 m^2 and wall thickness of 2.0 cm. It is filled with ice, water, and cans of 100 Plus sports drink at 0 °C. (thermal conductivity for Styrofoam k = 0.01 W m^{-1} K^{-1}, the specific latent heat of fusion for ice = 3.34×10^5 J Kg^{-1})

(i) What is the rate of heat flow into the box if the temperature of the outside wall is 32 °C?

(ii) If under the same circumstances, how much ice melts in one day?

(iii) Name the mechanism of heat transfer for this process. [19.2 W, 4.97 kg]

U97-12 Heat is conducted along a well-lagged uniform metal bar of cross-sectional area A at a steady rate Q from one end to the other end. The temperature difference between two points with a distance d apart on the axis of the bar is proportional to ___________.

A. QdA B. $\frac{Q}{Ad}$ C. $\frac{Qd}{A}$ D. $\frac{QA}{d}$

U97-13 Certain cooking pots can be transferred directly from the freezer to a hot oven without cracking up. These pots are made of materials that ________.

A. have low heat conductivity and expansivity
B. have high heat conductivity and expansivity
C. have a low heat conductivity and high expansivity
D. have a high heat conductivity and low expansivity

U2k08-P4 (b) A copper rod of length 200 cm and a steel rod of length l are joined end-to-end. Both rods have the same cross-sectional area of 6 cm^2 and are thermally well-insulated. The free ends of the copper rod and the steel rod are kept at constant temperatures of 120 °C and 0 °C respectively while the temperature at the copper-steel junction is 50 °C. If the thermal conductivities of copper and steel are 400 W m^{-1} K^{-1} and 80 W m^{-1} K^{-1} respectively, calculate:
(i) the rate of heat flow in the copper rod;
(ii) the length l of the steel rod.
[8.4 W; 28.6 cm]

U2k13-12 Four cylindrical copper rods of different radii and lengths are used to conduct heat between two heat reservoirs at fixed temperatures of θ_1 and θ_2 respectively. Which of the following copper rods will conduct the maximum quantity of heat per second?

A. Radius 1 cm, length 4 m B. Radius 2 cm, length 3 m
C. Radius 3 cm, length 2 m D. Radius 4 cm, length 1 m

U2k15-12 Fig.U2k15-12 shows the surface and interface temperatures of a composite slab consisting of four materials with different thickness, through which the heat transfer is steady. Arrange these materials according to their thermal conductivities, k in ascending order from the lowest to the highest.

A. $k_A < k_B < k_C < k_D$ B. $k_A < k_C < k_B < k_D$
C. $k_D < k_C < k_B < k_A$ D. $k_D < k_B < k_C < k_A$

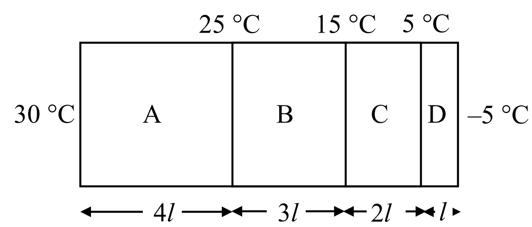

Fig.U2k15-12

U2k16-P5a Fig.U2k16-P5a shows a cylindrical water flask made of steel of radius 5 cm, height 25 cm and mass 800 g. A perfect heat insulation cup is provided. The flask is filled with 1.8 kg of hot water at 100 °C, and is fitted into a wooden case of thickness 2 cm. The temperature of its surrounding remains constant at 30 °C.
(i) Write down the equation of the rate of heat flow through a solid conductor;
(ii) Find the effective area of heat transmission through the wooden case;
(iii) Find the initial rate of heat flow through the wooden case;
(iv) Calculate the time taken for the temperature of the water in the flask to drop to 30 °C.
(Given: specific heat capacity of water = 4200 J kg^{-1} K^{-1}, and that of steel is 460 J kg^{-1} K^{-1}. The heat conductivity of wood is 0.15 W m^{-1} K^{-1})
[8.64×10^{-2} m^2; 45.36 J s^{-1}; 6.80 h]

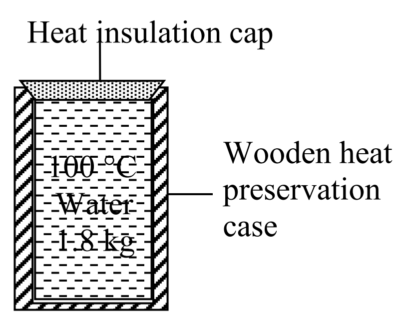

Fig.U2k16-P5a