Unit 12 · Rate of Heat Flow

WORKSHEET

Full marks 32

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 32

1 Key words [4]

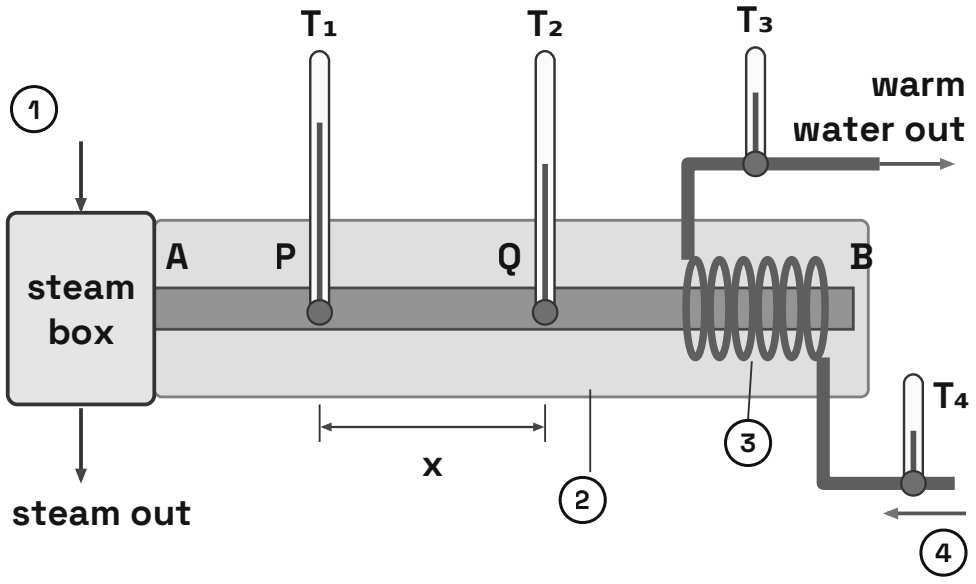
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

black body	conduction	convection	emissivity	evaporation	expansion	radiation
Stefan's law	temperature gradient	thermal conductivity				

Heat passes along a metal rod, particle to particle, by _____; it is carried by the moving fluid itself in _____; and it travels as electromagnetic waves, even through a vacuum, by _____. The fall of temperature per unit length along a rod is the _____. The rate of heat flow through a unit cube of a material with a unit difference of temperature across it is its _____. A body that absorbs all the radiation falling on it is a perfectly _____. The ratio of a surface's radiation to a black body's at the same temperature is its _____. The energy radiated per second per unit area by a black body is proportional to the fourth power of its absolute temperature: this is _____.

2 Label the diagram [2]

The diagram shows Searle's apparatus for the thermal conductivity of a good conductor. Write the part that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. The SI unit of thermal conductivity is: [1]

a. W/m
b. W/(m K)
c. J/(kg K)
d. $W/(m^2 K^4)$

ii. Heat from the Sun reaches the Earth by: [1]

a. conduction
b. convection
c. radiation
d. all three

iii. A surface reflects 30% of the heat radiation falling on it and transmits none. Its absorptance is: [1]

a. 0.3
b. 0
c. 0.7
d. 1.0

iv. A lagged rod 0.50 m long has its ends at 100 °C and 0 °C. In the steady state, the temperature gradient along it is: [1]

a. 50 K/m
b. 100 K/m
c. 200 K/m
d. 0.005 K/m

v. On a sunny afternoon, a sea breeze blows from the sea towards the land because: [1]

a. the sea is warmer than the land
b. the land heats faster than the sea, so warm air rises over the land and cooler air from the sea flows in
c. cold air sinks over the land
d. the Earth's spin drives it

4 Short answers [7]

Write short answers to the following questions.

a. Why are cooking pans made of metal, but their handles of wood or plastic? [2]

b. Why do we feel cooler in white clothes in summer? [2]

c. A brick wall of area 10 m^2 is 0.20 m thick. The room is at 20 °C and the outside at 5 °C. Find the rate at which heat is conducted through the wall in the steady state. (k for brick = 0.6 W/(m K)) **[3]**

5 Long answer **[4]**

Write a long answer to the following question.

Describe Searle's method for finding the thermal conductivity of a good conductor, and write the formula used.

6 Numerical problems **[7]**

Solve the following problems. Show your working.

a. A double-glazed window has two panes of glass, each 4.0 mm thick, with a 12 mm layer of still air between them. The room is at 22 °C and the outside at 2 °C. Find the rate of heat loss through each square metre in the steady state. Compare it with a single pane 4.0 mm thick. (k: glass 1.0 W/(m K), still air 0.026 W/(m K)) **[4]**

Answer:

b. A person's skin, of area 1.8 m^2, is at 34 °C, in a room whose walls are at 20 °C. Treating the skin as a black body, find the net rate at which the person loses heat by radiation. ($\sigma = 5.67 \times 10^{-8}$ W/(m^2 K^4)) **[3]**

Answer: _____

7 Think **[3]**

On the International Space Station, where things float, a candle burns with a small round flame and soon goes out. On the Earth its flame is long and keeps burning. Explain.

8 Activity: Which cup cools fastest? (not marked)

Pour equal amounts of hot water from the same kettle into three cups: a steel cup, a glass or ceramic cup, and a steel cup wrapped in a woollen cloth. Read the temperature of each every 2 minutes for 10 minutes.

Time (min)	Steel cup (°C)	Glass cup (°C)	Steel cup in wool (°C)
0			
2			
4			
6			
8			
10			

Which cup kept its water hottest? Why?