AQA Physics GCSE Student literacy sheet

P2.1

Name ..... Class ..... Date .....

Thermal conductivity

Specification reference:

- P1.2.1 Energy transfers in a system

Aims

This is an activity that has been designed to help you improve your literacy skills. In this activity you will learn more about thermal conductivity and the variables that cause bodies to heat up or cool down over time. You will practise answering questions that involve some of the key command words and scientific terms that you will encounter in the topic of thermal physics and heat transfer.

Learning outcomes

After completing this worksheet, you should be able to:

- define the term 'thermal conductivity'.
- state examples of materials with high and low thermal conductivities
- describe the relationship between thermal conductivity and heat transfer.
- explain why different materials have different thermal conductivities.
- apply an understanding of thermal conductivity to the design of buildings.
- analyse and compare materials based on their different thermal conductivities.

Setting the scene

Thermal conductivity relates to the rate of thermal energy transfer through different materials, and it has applications to areas in modern life such as the design and construction of buildings. This activity will allow you to think about the nature of thermal conductivity and consider the impact it has on heat loss and the design of homes when considering heat transfer.

Task

Read the information about thermal conductivity and heat transfer and then answer the questions that follow. This text extract relates to a practical investigation that can be conducted in a typical school laboratory to investigate the rate of thermal transfer. The data from the investigation can then be used to determine the suitability of a number of different materials for a number of purposes.

Thermal conductivity

In this investigation you will study thermal flow from a higher temperature to a lower temperature. This is often called a 'temperature gradient'. We compare the temperature difference across two materials (where the thermal conductivity of one of them is known). When both are conducting heat at a steady rate, you will be able to calculate the unknown thermal conductivity of the other material.

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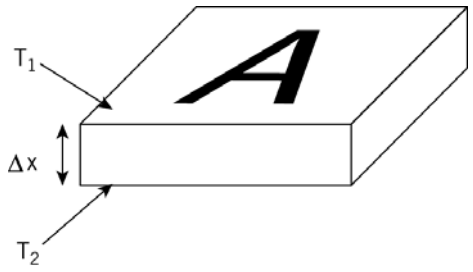
Thermal conductivity is an important concept in regard to heat transport in air. It is also essential for understanding the properties of insulating material such as the walls and windows of your house. Thermal conductivity is defined as the ability of a material to allow the flow of heat from its warmer surface through the material to its colder surface. This is determined as the heat energy transferred per unit time and per unit surface area divided by the product of the temperature difference between the surfaces and the thickness of the material. It is expressed in watts per kelvin per metre (or W/mK). Materials with low thermal conductivities are good insulators and those with high thermal conductivities are good conductors of thermal energy.

Temperature is a measure of the average kinetic energy of the random motion of molecules in a material. As the temperature of a material increases, the random motion of its molecules increases. The material absorbs and stores a quantity which we call heat. The material is then said to be 'hotter'. Heat was once thought to be a fundamental quantity specifically related to temperature, Now we know it is simply another form of energy.

As the molecules in one region of a material move, they collide with molecules in neighbouring parts of the material. In this way they transfer some of their energy to other regions. The net result is that heat flows from regions with higher temperatures to regions with lower temperatures.

In this investigation, we will consider the heat flow across a plate of material. Its cross sectional area is A and its thickness is Δx. We will keep its faces at constant, but different, temperatures, as shown here in Fig. 1.



In this case the rate of heat flow Q across the material is given by

$Q = kA(\Delta T / \Delta x)$ where $\Delta T = T2 - T1$ is the temperature difference across the plate and k is a quantity called the thermal conductivity.

Note that this equation only applies because we keep the top and bottom at two different, but fixed temperatures. In a more general situation, the flow of thermal energy would alter the temperature of the top and bottom, and a more complicated approach would be required to deal with the situation.

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Questions

1 Define the term 'thermal conductivity'.

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..... (*2 marks*)

2 **a** Give three examples of materials that have:

i a high thermal conductivity

..... (*1 mark*)

ii a low thermal conductivity

..... (*1 mark*)

b Explain your reasoning for your answers in part **a**

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..... (*5 marks*)

3 **a** Explain why the thermal conductivity value of a material is an important consideration when building properties.

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..... (*2 marks*)

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b Give three examples of the types of materials that would be used when building houses where their thermal conductivity would need to be considered.

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c In addition to thermal conductivity, what other properties of materials would need to be considered when designing and building houses? Give three suggestions.

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..... (*3 marks*)

4 Explain how the thermal conductivity of a material needs to be considered in the following situations:

a the outer surface panels of the space shuttle

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..... (*3 marks*)

b the material used to make a pizza oven wall (or kiln wall)

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..... (*2 marks*)

c the material used in phones that is used to package semiconductors and integrated circuits.

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