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FREE LEARNING NOTES FOR ZAMBIA

FORM 2

Physics

Heat transfer and the measurement of heat

Lesson notes for learners · Competence-Based Curriculum

INSIDE

1. Conduction
2. Convection
3. Radiation
4. Keeping things hot or cold
5. Measuring heat
6. Check yourself

On a cold evening in Lusaka you may warm your hands at a charcoal brazier, feel the sun on your face, or notice a metal spoon getting hot in a pot of nshima. Heat moves in different ways in each case. In this note you learn the three ways heat is transferred, how to keep things hot or cold, and the terms used to measure heat.

AFTER THESE NOTES YOU SHOULD BE ABLE TO

- Describe conduction, convection and radiation
- Explain why metals are good conductors and plastics are insulators
- Explain how dark and light surfaces absorb or reflect radiation
- Explain how a convection current forms
- Define heat capacity, specific heat capacity and latent heat

KEY WORDS

conduction	the transfer of heat through a material as its particles pass on energy
convection	the transfer of heat by the movement of a heated liquid or gas, which rises while cooler fluid sinks
radiation	the transfer of heat by infrared rays, which does not need a material to travel through
insulator	a poor conductor of heat
heat capacity	the heat energy needed to change the temperature of a substance by 1 °C or 1 K
specific heat capacity	the heat energy needed to change the temperature of 1 kg of a substance by 1 °C or 1 K
latent heat	the heat energy needed to change the state of a substance without changing its temperature
specific latent heat of fusion	the energy needed to change 1 kg of a substance from solid to liquid without changing its temperature

1 Conduction

Hold a metal spoon and a plastic spoon in hot water. The metal spoon quickly becomes too hot to hold, but the plastic one does not. A metal is a good conductor of heat. Its particles vibrate vigorously and pass kinetic energy on quickly to the next particles, and so to your hand. Plastic is a poor conductor, called an insulator, so energy moves through it very slowly.

This is why saucepans have wooden or plastic handles: they are poor conductors, so heat does not reach the hand and burns are avoided.

2 Convection

Heat is also carried by moving air or liquid. Air above a fire is heated and rises. It then spreads out, cools and sinks back down towards the fire, forming a continuous loop called a convection current.

The same idea keeps a refrigerator cold. Cold air near the cooling coils is denser and sinks, while warmer air rises. This flow keeps the temperature low and even throughout the fridge.

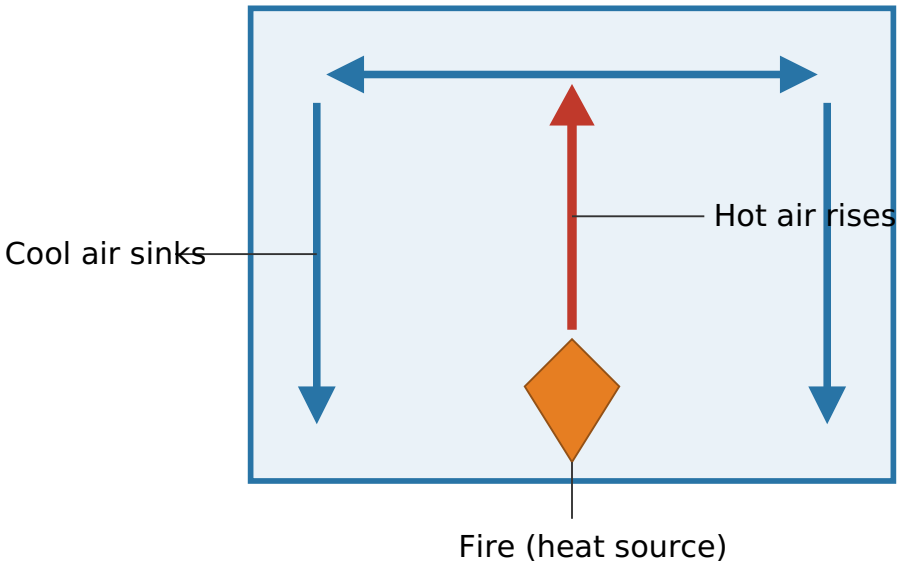

Figure 1. A convection current above a fire

3 Radiation

Heat from the sun reaches us by radiation, in the form of infrared rays. Dark, dull or black surfaces are good absorbers of radiation, and light, shiny surfaces are good reflectors, so they stay cooler. Good absorbers of radiation are also good emitters.

This is why people prefer to wear light clothes on a hot day, and why shiny aluminium foil is used to reflect heat.

4 Keeping things hot or cold

We can use these ideas to reduce heat loss. Suppose a family wraps hot food in aluminium foil and puts it in a cardboard box lined with old newspapers and cotton cloth for a long car trip. Each material stops a different kind of heat transfer.

Material	Heat transfer reduced	How
Aluminium foil (shiny)	Radiation	Reflects heat back
Newspaper and cotton cloth	Conduction	Poor conductors
Cardboard box	Convection	Limits the movement of air

Figure 2. How each material reduces heat loss

5 Measuring heat

Heat capacity is the heat energy needed to change the temperature of a substance by 1 °C or 1 K. Specific heat capacity is the heat energy needed to change the temperature of 1 kg of the substance by 1 °C or 1 K.

Latent heat is the heat energy needed to change the state of a substance without any change in temperature. The specific latent heat of fusion is the energy needed to change 1 kg of a substance from solid to liquid, for example ice to water, without changing its temperature. The specific latent heat of vaporisation is the energy needed to change 1 kg of a substance from liquid to gas at its boiling point, for example water to steam, without changing its temperature.

WORKED EXAMPLE

A substance needs 4200 J to raise the temperature of 1 kg by 1 °C. How much heat does 2 kg need to rise by 3 °C?

4200 J is needed for 1 kg to rise by 1 °C

For 2 kg, the heat doubles: 4200 × 2 = 8400 J for 1 °C

For a rise of 3 °C, the heat triples: 8400 × 3 = 25 200 J

So 2 kg needs 25 200 J

TRY THIS

Hold a metal spoon and a plastic spoon in a cup of hot water and feel which one warms up faster. Then place a black cloth and a white cloth in the sun for the same time and feel which one is warmer. Write down which heat transfer process each activity shows.

REMEMBER

- Heat moves by conduction, convection and radiation
- Metals are good conductors; plastics and wood are insulators
- In convection, hot fluid rises, cools and sinks in a convection current
- Radiation is infrared rays; dark dull surfaces absorb well and shiny light surfaces reflect
- Heat capacity is the heat needed to change a substance's temperature by 1 degree; specific heat capacity is the same for 1 kg
- Latent heat changes the state of a substance with no change in temperature

? Check yourself

1. Name the three ways in which heat is transferred.
2. Why is a plastic spoon better than a metal spoon for stirring hot food?
3. What is a convection current?
4. What is the difference between heat capacity and specific heat capacity?
5. What happens to the temperature of ice at 0 °C as it melts, and what is the heat called?
6. You are a learner at a school in Luangwa. On a hot afternoon you notice that a black school bag left in the sun is much hotter than a white one. (a) Which heat transfer process brings the heat from the sun? (b) Explain why the black bag becomes hotter. (c) Suggest what colour of cloth is best for a
7. A learner in Lusaka puts 200 g of ice at 0 °C into a metal cup, then heats it. The ice melts and then the water warms up. (a) Name the heat concept for melting the ice without a change in temperature. (b) Say why the temperature stays constant while it melts. (c) Say which concept is used for the he

ANSWERS

1. Conduction, convection and radiation.
2. Plastic is a poor conductor (an insulator), so heat passes through it very slowly.
3. The continuous loop in which hot air or liquid rises, cools and sinks again.
4. Heat capacity is for a whole substance and specific heat capacity is for 1 kg of it.
5. It stays constant; the heat is latent heat (of fusion).
6. (a) Radiation. (b) Dark, dull surfaces are good absorbers of radiation, while light surfaces reflect it. (c) Light or white cloth, because it reflects more radiation and stays cooler.
7. (a) Latent heat, the latent heat of fusion. (b) The heat energy is used to change the state of the substance, not to raise its temperature. (c) Specific heat capacity.

Written by 25Schools to follow the Form 2 Physics syllabus of the Zambian competence-based curriculum. Free for learners to read, download and share. More notes and quizzes at 25schools.com.